COMPARATIVE EVALUATION OF FORMOCRESOL AND MINERAL TRIOXIDE AGGREGATE AS A PULPOTOMY AGENT

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Certificate

This is to certify that this dissertation entitled **"Comparative Evaluation Of Formocresol And Mineral Trioxide Aggregate As A Pulpotomy Agent"** *is a bonafide record of work done by* **Dr. Daya Srinivasan**, *Post graduate student in the Department of Pedodontics and Preventive Dentistry, Ragas Dental College and Hospital, Chennai, under my supervision and guidance during her post graduate period between 2005 – 2008.*

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Introduction

Preservation of primary teeth, which has been affected by carious lesion or trauma, forms a major problem in pediatric dental practice. The principle of pulp treatment in primary dentition is that tooth should remain in mouth in a non-pathological healthy condition to fulfill its role in primary dentition. Maintenance of primary tooth is important for development of arch form, esthetics, function, and mastication and also for normal emergence of permanent teeth.

There are numerous pulpal procedures indicated in primary tooth. Pulpotomy is indicated when caries removal results in pulp exposure of primary tooth with normal or reversible pulpitis or after traumatic pulp exposure. The coronal pulp tissue is amputated and remaining radicular pulp tissue is judged to be vital by clinical and /or radiographic criteria. The objective is that radicular pulp should remain healthy without adverse clinical signs or symptoms such as sensitivity, pain or swelling. There should be no postoperative radiographic evidence of pathologic external or internal root resorption and no harm to succedaneous teeth. (AAPD 2004)

Pulpotomy in primary dentition is developed along three lines-Devitalization, Preservation and Regeneration. Devitalization, - destroy the vital tissue example: Formocresol, electrosurgery. Preservation- maximal vital tissue is kept with no induction of reparative dentine-example glutaraldehyde. Regeneration, stimulation of dentine bridge – example Mineral Tri oxide Aggregate (MTA), Bone Morphogenic protein (BMP), osteogenic protein.

For decades formocresol has been widely used as pulpotomy medicament. It is used as standard for comparison of other materials. Yet there have been many concerns about the usage of formocresol like reports of positional alteration, enamel defects of sucedaneous tooth [30] (Rolling and Poulsen 1978), premature exfoliation of pulpotomized tooth when compared to its antimere[24]. In June 2004 International agency of cancer IARC of WHO has stated that formaldehyde causes nasopharyngeal cancer, limited evidence that it causes nasal and para nasal sinus carcinoma and strong but not sufficient evidence that formaldehyde causes leukemia in humans.

Criticism of formocresol has encouraged the search for newer alternatives. MTA introduced by Torabinejaad in 1993 has been useful in variety of clinical situations such as pulp capping, pulpotomy, and root end closures [43]. Its main components are tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicon di -oxide. Bismuth is added to get radiopacity [7]. It's mechanism of action is similar to calcium hydroxide and induces osteogenic phenotype activities like alkaline phosphatase, osteonidogen, osteonectin, osteocalcin, osteopontin [5] and results in hard tissue bridge formation.

It is currently available as two brand names, MTA Pro root (Densply) and MTA Angelus. The brands do not interfere with cytokine response by the macrophages [39]. Some of the previous studies have found better result when compared with other medicaments [2, 12, 14, 32, 6]. It is available as grey and white types. Between the

two types of MTA grey appears to have better marginal adaptation and seal ability when compared with white MTA (Myriam, Bidar 2007).

Thus this study has been undertaken to evaluate and compare the MTA and Formocresol as a pulpotomy medicament.

Aims & Objectives

Aims and Objectives

- To evaluate and compare MTA and Formocresol as a pulpotomy medicament by clinical and radiographic assessment.

- To assess the histological features of MTA and Formocresol as pulpotomy medicaments.

Review of Literature

A.M.Lauterstein, S.Pruzansky et al 1962[24] studied the effect of deciduous mandibular molar pulpotomy on the eruption of succedaneous premolar. 28 children requiring pulpotomy on mandibular molars were included in the study. They were observed for a period of 4 years. Measurements pertaining to eruption of premolar teeth were obtained from oblique roentgenograms. It was seen when compared with eruption status of normal antimere, the succedaneous premolar beneath the pulpotomized teeth demonstrated significantly accelerated tendency to erupt.

Robert H. Spedding, David F. Mitchell et al 1965[44] evaluated the effects of Formocresol and calcium hydroxide therapy on both primary and permanent teeth. The sample consisted of 36 primary and 12 young first permanent molars in 3 monkeys approximately 20 months old. 21 teeth were treated with formocresol, and 15 of these were observed to be "fixed" to an apical half or third depth. 20 contained vital tissue in the apical third, half, or greater portion of the canals. One tooth was not available for study and was considered a failure. Dentin chips obstructing the canals of 5 teeth apparently prevented pulpal fixation. 3 pulps treated with formocresol revealed fixed pyknotic leucocytes dispersed among an excess of dentin chips blocking the root-canal entrances, and 2 pulps were observed to have leucocytes in the apical area. One of these 2 pulps was necrotic in the remaining portion of the canal, and the other pulp revealed peculiar syncytium in the apical third of the canal in which scattered inflammatory cells were observed. Successful treatment was at a 70 % level. 15 of 25 teeth treated

with Calcium hydroxide presented normal non-inflamed tissue. 10 teeth had inflamed or necrotic pulp tissues and the range of inflammation were judged to be from mild to severe. 60 % of the 25 teeth were successfully treated. No apparent differences were noted when comparing the effects of the pulp-dressing materials on the primary and the permanent teeth, with the exception of osteodentin, which was observed in the primary teeth treated with both pulp-dressing materials. The results of this study gave the impression that the formocresol pulp therapy is superior to the calcium hydroxide pulp therapy- for primary teeth.

Louise B. Messer, Jay T. Cline 1980[30] evaluated the long-term effects of primary molar pulpotomies on succedaneous bicuspids. A total of 63 primary molar pulpotomy was done on teeth in children aged 5-11 years. Preoperative clinical and intra oral radiographs showing the periapical and interradicular areas of test molars and also the position and extent of development of all the bicuspids were recorded. The contra-lateral, adjacent and opposing bicuspids, not preceded by test molars, were designated control bicuspids (total 205) distributed as follows: maxillary first - 58; maxillary second - 56; mandibular first - 49; mandibular second - 42. In the control group, there were four congenitally missing bicuspids. Forty-three bicuspids which replaced successfully Buckley's formocresol pulpotomized vital or non-vital primary molars, and twenty bicuspids, which erupted following unsuccessful pulpotomies requiring extraction of the preceding teeth, were examined for defects of position and enamel. In

comparison with contra lateral control tooth, test teeth in both the groups showed increased prevalence of rotation and enamel defects.

Edna L.Pashley, Myers 1980[34]-studied fate of the 14C-formaldehyde, which was absorbed following its application to pulpotomy sites. Tissue binding accounted for most of the systemic absorption. Tissue binding was highest in the liver and lowest in skeletal muscle. The high amount of 14C-activity in bile correlated with the high liver tissue/plasma values and demonstrated formaldehyde concentration by the biliary system. Formocresol was absorbed and distributed rapidly and widely throughout the body within minutes of being placed on a pulpotomy site.

D.M. Ranly, Horn et al 1985[36] compared the antigenicity of the reaction products of protein with formaldehyde, glutaraldehyde, or dimethylsuberimidate (DMS). Rabbits were injected with rabbit serum albumin (RSA) which had been treated with one of the following solutions: phosphate-buffered saline, 2% glutaraldehyde, 4% formaldehyde, or 2% DMS. The antisera from the rabbits were analyzed for elicited antibodies by the enzyme-linked immunosorbent assay (ELISA) and in a horseradish peroxidase (HRP) assay using a spot technique on nitrocellulose paper. The assays demonstrated that DMS-treated RSA was the most antigenic of the reaction products tested. The least provocative was

the glutaraldehyde-treated RSA; the reaction product of formaldehyde was intermediate.

Inoue H, Muneyuki H et al 1997[20] studied nerve terminals formation during dentin bridge formation after pulpotomy in dog teeth using electron microscope. The relationship between pulpal nerves and the differentiation of pulpal cells into preodontoblast and odontoblast during the healing process after pulpotomy was studied. A total of 36 upper and lower teeth obtained from six adult dogs were used. The pulp chamber was opened with a sterile diamond bur, the coronal pulp was exposed, and the whole surface of the amputated pulp was capped with calcium hydroxide. The interval between pulpotomy and extraction was 5, 7, 10, 15, 20, 30, 40, 50, and 60 days, and then specimens were examined ultra structurally. Close contact between fibroblast-like cells/osteoblast-like cells and nerve terminals at the calcification front was observed in the early healing process after pulpotomy, suggesting a close relation between nerve fibers and pulpal cell differentiation.

Waterhouse PJ, Nunn JH et al 2000[49]- Evaluated the efficacy of calcium hydroxide and Formocresol pulpotomy by comparing clinical, radiographic and histological outcomes. 52 child patients were sequentially enrolled in the longitudinal clinical investigation, 26 boys and 26 girls. Primary molar teeth requiring vital pulp therapy were randomly allocated to either the formocresol

group (F) or the calcium hydroxide group (C). Coronal pulp amputation was prescribed only in teeth with vital, cariously exposed pulp tissue. 74 teeth were included in group F and 35 in group C. 5% (n = 2) of teeth in group F and 11 % of teeth (n = 4) in group C were terminated from the trial due to clinical and/or radiographic failure. Of the 6 teeth extracted, 5 were sufficiently intact to be retained for histological evaluation. Post-extraction radiographs were taken before specimen preparation, showed reactionary dentine barrier (bridge) formation in teeth treated with calcium hydroxide. Narrowing of root canals, indicative of appositional reactionary dentine deposition, was seen in both groups (F and C). Histological examination revealed that pus cells were evident in all specimens examined. There was also histological evidence of resorption of reactionary dentine within the root canal and that forming the calcified barrier (dentine bridge).

P. J. Waterhouse, J H Nunn et al 2000[48] compared the clinical and radiological outcomes of Formocresol and calcium hydroxide pulpotomy. Forty-six carious primary molars were included in-group F (formocresol). The teeth were treated by coronal pulp amputation followed by a five-minute application of a 20% Buckley's Formocresol solution to radicular pulp stumps. Thirty-eight carious primary molars were included in-group calcium hydroxide. Fifty-two patients were involved in the investigation (26 female and 26 male). Forty-six teeth were treated with formocresol and 38 teeth with calcium hydroxide. However, 5 treated teeth from 3 patients were lost to follow-up, leaving 44 in group F and 35 in group C. Eighty four percent (37/44) of teeth treated with formocresol and 77

percent (27/35) treated with calcium hydroxide were classified as clinically and radiographically successful, after a mean clinical review of 22.5 months (range 6.1–38.5 months) and a mean radiographic review of 18.9 months (range .3–36.9 months). This investigation confirmed the clinical efficacy of a one-fifth dilution of Buckley's Formocresol as an agent in pulp treatment of cariously exposed, vital primary molar teeth.

Holland, Valdir de Souza, Sueli Satomi Murata in 2001[16]- studied the healing process of dog dental pulp after pulpotomy and pulp covering with MTA or Portland cement (PC). After pulpotomy, the pulp stumps of 26 roots of dog teeth were protected with MTA or PC. Sixty days after treatment, the animal was sacrificed and the specimens removed and prepared for histo - morphological analysis. There was a complete tubular hard tissue bridge in almost all specimens. In conclusion, MTA and PC show similar comparative results when used in direct pulp protection after pulpotomy.

Holland, Valdir de Souza, Mauro Juvenal Nery in 2001 [17] performed a study to observe the rat subcutaneous connective tissue reaction to implanted dentin tubes filled with mineral trioxide aggregate, Portland cement (PC) and calcium hydroxide (CH). The animals were sacrificed after 7 or 30 days and the decalcified specimens were prepared for histological analysis with polarized light and Von Kossa technique for mineralized tissues. It was concluded that MTA and PC encouraged hard tissue deposition similar to CH.

Schmitt, D., J. Lee et 2001[43]- reviewed on multi faceted usage of MTA. MTA's physical and biological properties and the clinical techniques of direct pulp capping, apexification, and repair using MTA where calcium hydroxide therapy failed were discussed.

Strange DM, Seale NS et al 2001[46]-performed a retrospective study on 196 primary molars (follow up=6 to 103 months; mean=49 months) on patients who received formocresol pulpotomies with the application of formocresol in the zinc oxide-eugenol sub-base. Traditional assessment of radiographic success and failure had yielded a success rate of 79%. Alternative assessment excluding internal resorption as a failure had yielded 99% success rate. Most frequently observed pulpal responses were calcific metamorphosis and internal resorption. Overall clinical success was 99%. The overall success rate has indicated that the formocresol pulpotomy technique incorporating formocresol in the zinc oxide-eugenol sub-base can be a treatment modality for primary molars requiring pulp therapy.

Holan G, Fuks AB, Keltz N 2002[15]- performed a retrospective study to compare the success rates of formocresol pulpotomy in primary molars restored with stainless steel crowns (SSC) to those restored with amalgam (AM). Pulpotomized primary molars restored with SSC or AM were evaluated and defined as a "failure" when one or more of the following signs were present: internal (IR) or external (ER) root resorption and periapical (PR) or inter-radicular (IRR)

radiolucency. Pulp canal obliteration was not regarded as failure. 341 molars were available for follow-up evaluations ranging from 6 to 103 months. 47 (14%) teeth were defined as "failure," with a rate of 13% (36/287) for teeth restored with SSC and 20% (11/54) for AM. This difference was not statistically significant (P>0.1). Failure rates of 2 surfaces AM were 23% (7/30), much higher than that of one surface AM (10%, 2/20). Most of the failed teeth presented more than one pathologic finding, with IR being the most frequently observed (36%), followed by ER (31%), IRR (22%) and PR (11%). Pulp canal obliteration was detected in 80% of the teeth, with similar rates in both groups. Pulpotomized primary molars can be successfully restored with one surface amalgam if their natural exfoliation is expected within not more than two years.

King SR, McWhorter et al 2002[23] – conducted a survey on the usage of Formocresol among the practicing pediatric dentist. 84% of the respondents use formocresol for their primary tooth pulpotomies. Of those, 69% use full strength, 27% use diluted and 4% don't know. Sources of diluted formocresol for those who use the diluted form include: 34% who buy it that way, 58% who dilute it themselves and 8% who have the pharmacy dilute it. Thus majority of pediatric dentists who use formocresol for primary tooth pulpotomies use a full strength formulation.

Andelin WE, Shabahang S et al 2003[4]-Compared the efficacy of MTA & BMP-7 as pulp capping material. The hard tissue formed early in experimental pulp exposures capped with mineral trioxide aggregate (MTA) or bone morphogenetic

protein (BMP)-7 using dentin sialoprotein (DSP) as a marker was tested. The pulps were capped with MTA alone as a pulp-capping agent and final restoration or with BMP-7 followed by restoration with MTA. The specimens were prepared and evaluated histologically and with immunohistochemistry using polyclonal antibodies raised against rat DSP. Pulps capped with MTA formed hard tissue that demonstrated significantly more immunostaining for DSP compared with BMP-7 ($p = 0.0031$). MTA-capped pulps also showed significantly more complete bridge formation compared with BMP-7 ($p = 0.0008$). Pulps capped with BMP-7 demonstrated a hard tissue that was bone-like in appearance and devoid of DSP staining.

Dominguez Ms, WitherspoonDE et al 2003[10]- Histologically assessed various vital pulp-therapy materials. Pulp capping and pulpotomy procedures were performed on 15 mongrel dogs. Three materials were used: calcium hydroxide, acid-etched dentin bonding, and mineral trioxide aggregate. Histologically mineral trioxide aggregate was a considerably better material than calcium hydroxide or acid-etched dentin bonding in maintaining the integrity of the pulp

Hunter ML 2003[18]-presented a paper on a case of premature exfoliation of primary molars that may be related to the use of formocresol in a multivisit pulpotomy technique.

Josette Camilleri, Franco E. Montesin et al 2003[7] – carried out a study to determine the constitution of a commercially available root-end filling material,

mineral trioxide aggregate, (MTA) (ProRoot MTA, Tulsa Dental, Tulsa, OK, USA). Results showed that white MTA was composed primarily of calcium, silicon, bismuth and oxygen, while the gray MTA had small pecks of iron and aluminum. The XRD analysis showed gray MTA to be composed primarily of tricalcium silicate and dicalcium silicate. The surface morphology of the materials differed under the various conditions, particularly following immersion in phosphate solution with crystal formation. The commercial versions of MTA were shown to have broadly similar constitution to ordinary Portland cement except for the addition of bismuth compounds. The white MTA did not contain iron.

Salko N, Joseph B, Juniad TA et al-2003[40] Compared bioactive glass, mineral trioxide aggregate, ferric sulfate, and formocresol as pulpotomy agents in rat molar. Pulpotomies were performed in 80 maxillary first molars of Sprague Dawley rats, and pulp stumps were covered with BAG, FC, FS, and MTA. Histologic analysis was performed at 2 weeks and then at 4 weeks after treatment. At 2 weeks, MTA samples showed some acute inflammatory cells around the material with evidence of macrophages in the radicular pulp. Dentine bridge formation with normal pulp histology was a consistent finding at 2 and 4 weeks with MTA. Ferric sulfate showed moderate inflammation of pulp with widespread necrosis in coronal pulp at 2 and 4 weeks. Formocresol showed zones of atrophy, inflammation, and fibrosis. Fibrosis was more extensive at 4 weeks with evidence of calcification in certain samples. Among the materials tested, MTA performed ideally as a pulpotomy agent causing dentine bridge formation while

simultaneously maintaining normal pulpal histology. It appeared that BAG induced an inflammatory response at 2 weeks with resolution of inflammation at 4 weeks.

Zarzar PA, Rosenblatt, Costa Jr et al-2003[50]- undertook a control study on mutagenicity of Buckley's original formulation. Lymphocyte cultures obtained from the peripheral blood of children aged from 5 to 10 years old was assessed. The sample comprised 20 children who had primary teeth with cariously exposed vital pulps. Two venous blood samples were collected (6-8 ml) from each child, the first prior to vital pulpotomy (control group) and the second 24 h after pulpotomy (treated group). The peripheral lymphocytes were grown in a complete culture medium consisting of 78% RPMI 1640 medium (a), supplemented with streptomycin (0.01 mg/ml), penicillin (0.005 ml (-1)), 20% fetal bovine serum (b) and 2% phytohemagglutinin (c). The cytogenetic analysis was blindly investigated. There was no statistically significant difference in clinical doses between the control and treated groups, for the chromosomal aberrations (P=0.251) and for the total chromosomal breaks (P=0.149). Although there were no statistically significant differences between the control and treated groups, Buckley's formocresol was mutagenic for one patient, raising doubt about the desirability of its use for pulpotomies in children. The results revealed that, from a statistical standpoint, formocresol was not mutagenic. However, further investigations are required, with a larger sample, in patients needing more than one pulpotomy in order to observe whether an increase in the quantity of the drug

would increase the quantity of chromosome aberrations and also to verify individual susceptibility to chromosome alterations with the usage of formocresol.

Agamy HA, Bakry NS et al 2004[2]-Evaluated the efficacy of gray MTA, white MTA and Formocresol as a pulpotomy agent in primary teeth. Twenty-four children, each with at least 3 primary molars requiring pulpotomy, were selected for study's clinical and radiographic portion. An additional 15 carious primary teeth planned for serial extractions were selected for this study's histologic portion. All selected teeth were evenly divided into 3 test groups and treated with pulpotomies. Gray MTA was used as the pulp dressing for one third of the teeth, white MTA was the dressing for one third, and the remaining one third were treated with formocresol. The treated teeth selected for the clinical and radiographic evaluations were monitored periodically for 12 months. The treated teeth selected for histologic study were monitored periodically and extracted 6 months postoperatively. Four children with 12 pulpotomized teeth failed to return for any follow-up evaluations in the clinical and radiographic study. Of the remaining 60 teeth in 20 patients, 1 tooth (gray MTA) exfoliated normally and 6 teeth (4 white MTA and 2 formocresol) failed due to abscesses. The remaining 53 teeth appeared to be clinically and radiographically successful 12 months postoperatively. Pulp canal obliteration was a radiographic finding in 11 teeth treated with gray MTA and 1 tooth treated with white MTA. In the histologic study, both types of MTA successfully induced thick dentin bridge formation at

the amputation sites, while formocresol induced thin, poorly calcified dentin. Teeth treated with gray MTA demonstrated pulp architecture nearest to normal pulp by preserving the odontoblastic layer and delicate fibrocellular matrix, yet few inflammatory cells or isolated calcified bodies were seen. Teeth treated with white MTA showed a denser fibrotic pattern, with more isolated calcifications in the pulp tissue along with secondary dentin formation. It's concluded that Gray MTA appears to be superior to white MTA and formocresol as a pulp dressing for pulpotomized primary teeth.

S. Bonson, B.G. Jeansonne et al 2004[5]- evaluated cytotoxicity of root end filling materials using gingival and periodontal fibroblasts. Many of the root-end filling materials examined were initially cytotoxic to both PDL and gingival fibroblasts in co-culture experiments; however, this was reduced after the materials were washed in either mineral trioxide aggregate (MTA) or hybrid ionomer composite resin (HICR) for 2 wks. PDL fibroblasts displayed enhanced proliferation on MTA and survival on amalgam when compared with gingival fibroblasts. MTA preferentially induced alkaline phosphatase expression and activity in both PDL and gingival fibroblasts. In contrast, HICR inhibited alkaline phosphatase expression and activity.

In addition, MTA and HICR repressed pleiotrophin in PDL fibroblasts, while HICR repressed periostin in both fibroblasts. Analysis of their data indicates that MTA generally induces an osteogenic phenotype (alkaline phosphatase,

osteonidogen, osteonectin, and osteopontin), while HICR tended to inhibit the expression of osteogenic transcripts (alkaline phosphatase, periostin, pleiotrophin).

S.E. Jabbarifar DD, A.A.Khademi DD 2004[21] *- compared success rate of Formocresol Pulpotomy versus Mineral Trioxide Aggregate in primary molar. 64 primary molars of children aged 5-8 years old, were pulpotomized by Formocresol (FC) or Mineral trioxide aggregate (MTA). The selected teeth were evaluated by clinical assess and radiographic periapical X-ray examination to be suitable for pulpotomy. 64 teeth in MTA pulpotomy and FC pulpotomy groups were examined during follow up. Two of second primary molars in MTA group and three of them in FC group showed internal root resorption. After 6 and 12 months, 60 teeth with MTA pulpotomy and FC pulpotomy did not show any clinical or radiographic sign and symptom. Success rate in MTA group was 93.75 percent and in FC group was 90.6 percent after one year. Average success and failure rates in two groups were 92.8 and 7.8 percent. Average differences between success and failure rates of two treatment methods were not significant. Findings of this study show that mineral trioxide aggregate can be an alternative procedure for FC pulpotomy of primary tooth.*

Kalskar RR, Damle S.G 2004[22]- compared the efficacy of lyophilized freeze-dried platelet derived preparation with calcium hydroxide as pulpotomy agents in primary molars. Fifty-six primary molars in 28 children were treated by a

conventional pulpotomy technique. 28 teeth were treated by lyophilized freeze-dried platelet derived preparation and another 28 by calcium hydroxide. Clinical evaluation was carried out at 1, 3, and 6-months interval and the radiographic evaluation was carried out at 1 and 6-months. The success rate of lyophilized freeze-dried platelet derived preparation proved better than calcium hydroxide..

Renato Menezes, Clóvis Monteiro Bramante et al 2004[27]- studied the pulp response of dog's teeth after pulpotomy and direct pulp protection with MTA Angelus and white Portland cement. Thirty-eight pulp remnants were protected with these materials. 120 days after treatment, the animals were sacrificed and the specimens removed and prepared for histological analysis. Both materials demonstrated the same results when used as pulp capping materials, inducing hard tissue bridge formation and maintaining pulp vitality in all specimens. The MTA Angelus and the white Portland cement showed to be effective as pulp protection materials following pulpotomy

Menezes R, Bramante, et al 2004[29]- investigated the pulpal response of dogs' teeth after pulpotomy and direct pulp protection with MTA Angelus, ProRoot, Portland cement and white Portland cement. Seventy-six teeth were treated with these materials. 120 days after treatment, the animals were sacrificed and the specimens prepared for histological analysis. All the materials demonstrated similar results when used as pulp-capping materials. Pulp vitality was maintained in all specimens and the pulp had healed with a hard tissue bridge. Thus the

materials used in the study were equally effective as pulp protection materials following pulpotomy.

H. Razmi, M. Zarrabian et al2004[38]- evaluated the tissue reaction to implanted MTA, Portland cement and Root MTA in the mandible of cats. Under asepsis condition and general anesthesia, a mucoperiosteal flap, following the application of local anesthesia, was elevated to expose mandibular symphysis. Two small holes in both sides of mandible were drilled. MTA, Portland cement and Root MTA were mixed according to the manufacturers, recommendation and placed in bony cavities. In positive control group, the test material was Zinc oxide powder plus tricresoformalin. In negative control group, the bony cavities were left untreated. After 3, 6 and 12 weeks, the animals were sacrificed and the mandibular sections were prepared for histologic examination under light microscope. The physical and histological results observed with MTA are similar to those of Root MTA and Portland cement. The authors suggest long- term studies with larger number of samples.

M. Gallas Torreira, A.A.Dos Santos et al 2004[47]- investigated bone response after implantation of MTA (Mineral Trioxide Aggregate) in the rabbit mandible. Experiments were carried out on the right mandibular body of 8 adult male rabbits. The animals were divided into two groups (control group and test group). In this in vivo study, MTA was used as an interpositional graft material in critical-size bone defects of rabbit mandibles. The animals were sacrificed on day 30 after surgery. The samples obtained from the mandibles were subjected to histological

procedures, which permitted the collection of sections with a thickness of 60±10μm. The sections were stained with Haematoxylin and Eosin and Goldner Trichrome stain and examined under a light microscope. No important inflammatory reactions were detected in any of the samples of the treated group. The results confirm the excellent biocompatibility of MTA. The implantation of MTA in bone defects led to bone regeneration 4 weeks after surgery. However, the growth rate was not significant and the amount of newly formed bone was limited with the use of MTA in this specific application. Sample examination did not suggest complete evidence of new bone growth from either an inductive or conductive perspective.

Alexandra Mussolino de Queiroz; Sada Assed et al 2005[3]- evaluated the biocompatibility of mineral trioxide aggregate (MTA) as a direct capping agent in dog's teeth. Class I cavities were prepared in 26 teeth from 3 adult dogs. MTA was applied over the exposed pulp in 13 teeth and paste of calcium hydroxide plus distilled water (control) was applied in the remaining 13 teeth. After 90 days, the animals were killed; the maxilla and mandible dissected and sectioned to obtain individual roots. Histologically pulp and periapical response observed with the use of MTA was similar to that of calcium hydroxide paste. MTA presented excellent response when used for direct pulp capping.

Casas, David J. Kenny 2005[8]- the authors' expresses at least 3 areas of concern with Formocresol usage: mutagenicity, carcinogenicity and immune sensitization. The formocresol pulpotomy, one-fifth dilution or full-strength, continues to be the

standard in many clinical trainings. Although many programs provide instruction of alternative techniques, less than a third offer clinical exposure to non aldehyde methods. The authors suggest alternatives to formocresol pulpotomy be used in future practice.

Farsi. N, Alamoundi N, et al 2005[12] compared clinically and radiographically, the mineral trioxide aggregate to formocresol when used as medicaments in pulpotomized vital human primary molars. The sample consisted of 120 primary molars; all teeth were treated with the same conventional pulpotomy technique. Sixty molars received FC and 60 received MTA throughout a random selection technique. At the end of 24 month, 74 molars (36 FC, 38 MTA) available for clinical and radiographic evaluation. None of the MTA treated teeth showed any clinical or radiographic pathology, while the FC group showed a success rate of 86.8% radiographically and 98.6% clinically. The difference between the two groups in the radiographic outcomes was statistically significant. It was concluded that MTA treated molars demonstrated significantly greater success. MTA seems to be a suitable replacement for formocresol in pulpotomized primary teeth.

Guelmann M, Mc Ilwain MF etal 2005[13]**-** retrospectively assessed the overall performance of formocresol pulpotomies in primary molars when definitively restored with a resin-based material; and compared the results to previously published studies using more traditional restorative techniques (stainless steel crown, amalgam). Radiographic success was determined by the absence of furcation/periapical osseous radiolucency and internal/external pathologic root

resorption. Patient's age, gender, tooth type and arch, follow-up time, ZOE base type used (IRM only or IRM with glass ionomer overlay), and number of surfaces involved were the variables analyzed in the study. Overall, restoration of pulpotomized primary molars with resin-based material was inferior to reported success rates using stainless steel crowns. When proximal surfaces were restored, the failure rate (26%) was comparable to amalgam (23%).

Holan G, Eidelman E, et al 2005[14]- assessed the effect of mineral trioxide aggregate and formocresol as pulp dressing material in primary molars. MTA group 33 teeth, FC group 29 teeth were followed up clinically and radiographically between 4 and 74 months. The mean follow-up time was 38 months. Twenty-nine teeth were followed until uneventful shedding (mean=33 months). Failures were detected after a mean period of 16 months (range=4 to 30). The success rate of pulpotomy was 97% for MTA (1 failure) and 83% for FC (5 failures). Eight teeth presented internal resorption. In 4 of them (2 of each group), progress of the resorption process stopped and the pulp tissue was replaced by a radiopaque calcified tissue. Pulp canal obliteration was observed in 58% of the MTA group and in 52% of the FC group (total=55%). MTA showed a higher (though not statistically significant) long-term clinical and radiographic success rate than formocresol, and can be recommended as its replacement as, unlike FC, MTA does not induce undesirable responses.

Huth KC, Paschos E et al 2005[19]- compared the relative effectiveness of the Er: YAG laser, calcium hydroxide, and ferric sulfate techniques with that of dilute

formocresol as pulpotomy agent. 200 primary molars in 107 healthy children were included and randomly allocated to one of the techniques. The treated teeth were blindly re-evaluated after 6, 12, 18, and24 months. After 24 months, the following total and clinical success rates were determined (%): formocresol 85 (96), laser 78 (93), calcium hydroxide 53 (87), and ferric sulfate 86 (100). Only calcium hydroxide performed significantly worse than formocresol ($p = 0.001$, odds ratio = 5.6, 95% confidence interval 2.0-15.5). In conclusion, calcium hydroxide is less appropriate for pulpotomies than formocresol.

Maroto M, Barberia E et al 2005[26] - evaluated mineral trioxide aggregate as a pulpotomy medicament in primary teeth. Seven patients were selected and a total of 20 molars and two canines were treated with pulpotomy procedures using MTA. After 6 months, 55% of the molars and 100% of the canines treated showed radiographic signs of dentin bridge formation. Also, 6 months after treatment, 60% of the molars showed root canal calcification (obliteration). Color change of the crown of the canines treated was noticeable. No clinical or radiographic signs of pathology were observed.

Marcella Fridland, Rafel Rosado 2005[25]**-** tested mineral trioxide aggregate solubility and porosity with different water-to-powder proportions. The study also determined the chemical composition of the salts by dissolving four sets of specimens using the following water-to-powder proportions were prepared: 0.26, 0.28, 0.30, and 0.33 grams of water per gram of cement. The latter is the ratio

recommended by the manufacturer. It was determined that the degree of solubility and porosity increased as the water-to-powder ratio increased. Significant differences were found among the sets of specimens. The chemical analyses of the salts dissolved by in the water identified the presence of calcium as the main chemical compound. The pH level of the solution was highly alkaline, ranging between 11.94 and 11.99. It can be stated that the calcium found in the solution should be in its hydroxide state at this high pH level. This ability to release calcium hydroxide could be of clinical significance because it could be related to proven capacity to induce mineralization.

JVN Menezes, Granjeiro et al 2005[28]**-** studied in-vitro toxicity of primary teeth pulpotomy agents based on MTT cell proliferation test and Neutral Red uptake colorimetric essays. Buckley's formocresol (FC), 20% diluted formocresol (FCD), calcium hydroxide P.A. (HC), 15,5% ferric sulfate solution (SF) and mineral trioxide aggregate (MTA) was tested on Balb-c 3T3 mouse fibroblasts. The cells were seeded in 24-well culture plates at a density of 3.104 cells/well and incubated for 24 h. to allow attachment. Extracts from the substances were obtained according to ISO 10993-12 standards. After incubation at a 37oC temperature in air atmosphere of 5% of CO2, medium was aspirated and replaced with 1, 0 ml of the extracts. The plates were incubated for 24 h. and the cytotoxicity was assessed in a spectrophotometer. The absorbance was read at 560 nm. There were two independent experiments in triplicates. Mean test absorptions were calculated and expressed as a percentage of the control cells together with

standard deviations. The results showed that the cytotoxicity can be ranked as: FC>FCD>SF>HC>MTA. Neutral Red test results showed that cells exposed to MTA, HC and SF did not affect the cells, when compared with control group, while FC and FCD reduced cell viability in approximately 65 %, when compared with control ($p<0,05$). The MTT assay demonstrated that the cytotoxicity of the materials can be ranked as: FC>FCD>SF>HC>MTA, with all the substances statistically significant different compared with control cells ($p<0.01$). Thus MTA was the less cytotoxic pulpotomy agent.

Naik S, Hegde AM 2005[32]- tested clinically MTA as a pulpotomy agent. 50 primary molars in children whose pulpal status warranted pulpotomy were randomly assigned to either control (formocresol) or experimental (MTA) group of 25 teeth. Each. Following pulpotomy all the 50 teeth were restored with stainless steel crown after 24 hours. Finally the patients were recalled after 1 month, 3 months and 6 months respectively and evaluated clinically and radiographically. Of the 50 teeth selected, 3 were not available for further follow-up after 1 month. The follow up after 1 month, 3 months and 6 months did not reveal any clinical or radiographic pathological findings in the rest of the 47 teeth. Hence, no statistical analysis was performed regarding the success of the treatment. The only significant findings were the discoloration of 60% of the teeth where MTA was used as a medicament after 24 hours, but which was later masked by restoring with a stainless steel crown

Rezende, T. M. B.; Vargas et al 2005[39] -tested the effect of two commercial brands of grey mineral trioxide aggregate (ProRoot® and MTA-Ângelus®) on cytokine production by M1 and M2 inflammatory macrophages. M1 and M2 peritoneal inflammatory macrophages were obtained and cultured in vitro in the presence of MTA. The cellular viability and the production of tumour necrosis factor-α, interleukin (IL)-12 and IL-10 in response to stimulation with interferon-γ and Fusobacterium nucleatum or Peptostreptococcus anaerobius were evaluated. Results showed that cements did not interfere with cellular viability or with cytokine production by either type of macrophage. However, M2 macrophages produced higher levels of IL-10 when stimulated with F. nucleatum than M1 macrophages ($P<0.05$). Thus brands of MTA evaluated did not interfere in the cytokine response by M1 or M2 macrophages to the two bacteria tested. However, a difference in cytokine production between the two types of macrophages was found.

N.k Sarkar, R.Caicedo et al 200542- Studied interactions of mineral trioxide aggregate with a synthetic tissue fluid using inductively coupled plasma—atomic emission spectroscopy, scanning electron microscopy, energy dispersive X-ray analysis, and X-ray diffraction. Mineral trioxide aggregate released its metallic constituents and produced precipitates with a composition and structure similar to that of hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$–HA]. The authors conclude that Ca, the dominant ion released from mineral trioxide aggregate, reacts with phosphates in synthetic tissue fluid, yielding hydroxyapatite. The dentin—mineral trioxide

aggregate interfacial layer results from a similar reaction. The sealing ability, biocompatibility, and dentinogenic activity of mineral trioxide aggregate is attributed to these physicochemical reactions.

Saltzmann B, Sigal M, Clokie C et al 2005[41]- evaluated laser-MTA and Formocresol pulpotomy technique. A total of 26 pairs of teeth from 16 patients were selected based on clinical and radiographic criteria with mean age=5.10 years. One tooth from each pair was randomly assigned to either the laser-MTA pulpotomy group or the formocresol-ZOE pulpotomy group. All teeth were followed up clinically and radiographically at 2.3, 5.2, 9.5 and 15.7 months. The laser-MTA pulpotomy showed reduced radiographic success rates compared to the formocresol-ZOE pulpotomy at 15.7 months; however, these results were not statistically significant.

R Caicedo, PV Abbott 2006[6]- analyzed clinical, radiographic and histological effects of mineral trioxide aggregate as a direct pulp capping and pulpotomy agent of primary teeth. After pulp treatment teeth were reviewed after one month, two months, three months, four months, and five months and immediately before extraction, which was typically about six months following the operative procedure. At each review appointment, the presence or absence of the following was assessed clinically: pain; tenderness to percussion; gingival inflammation; exudate; draining sinus; mobility and pulp status. Radiographs were taken prior to treatment, after one month and prior to extraction – these were compared to assess whether any root resorption, widening of the periodontal ligament space, or

periapical and furcation radiolucencies had developed following treatment. Development of periodontal pockets and dentinal bridges were also noted. After the teeth were extracted, they were fixed in formalin, stained with H & E stain, and then examined under a light microscope. Histologically, the presence of intrapulpal calcifications, dentinal bridges, odontoblasts, cementum formation, pulp tissue, inflammatory infiltrate and internal resorption were evaluated

Chacko V, Kurikose S 2006[9]-Histologically evaluated changes in the dental pulp following pulpotomy on premolar teeth that were to be extracted for orthodontic reasons with Mineral Trioxide Aggregate or Calcium hydroxide.. The teeth were extracted at 4 and 8-week intervals, fixed in 10% formalin and then kept in 5% nitric acid for 28 days for demineralization. Longitudinal sections were then prepared and viewed under light microscope. The pulps capped with MTA (at the end of 4 weeks and 8 weeks) showed dentin bridge formation, which was more homogenous and continuous with the original dentin when compared to the pulps, capped with calcium hydroxide. The pulpal inflammation was also less in the MTA group as compared to the calcium hydroxide group at the end of 4 and 8 weeks.

Duggal M, Al Ansary M 2006[11]-compared pulpotomy technique using mineral trioxide aggregate, formocresol as a pulp dressing. Follow-up clinical (not blind) and radiographic (blind) assessments were undertaken every 6 months. Time elapsed between treatment and either 1) detection of pulpotomy failure 2) natural

exfoliation of tooth 3) patient's last visit for recall. Pulpotomy success rate = (number of teeth in which pulpotomy did not fail)/ (total number of treated teeth) ×100. In total, 62 pulpotomized teeth were reviewed for analysis, 29 in the FC group and 33 in the MTA group. Treatment failure occurred in six teeth (one treated with MTA and five with FC) after a mean of 16 months (range, 4–30 months). Pulpotomy success rates were 97% for MTA and 83% for FC. The mean follow-up time was 38months (range, 4.–74 months), in which there was no significant difference between test and control groups. No statistically significant difference was found in the success rates of MTA and FC

Milnes AR, 2006[31] - discussed recent research about formaldehyde metabolism, pharmacokinetics and alleged carcinogenicity risk. Critical analysis of previous published results indicates that formaldehyde is probably not a potent human carcinogen under conditions of low exposure. Extrapolation of these research results to pediatric dentistry suggests an inconsequential risk of carcinogenesis associated with formaldehyde use in pediatric pulp therapy. Areas for further investigation are suggested.

H. Neamatollahi, A. Tajik 2006[33] - compared clinical and radiographic success rates of pulpotomy in primary molars using Formocresol, Ferric Sulfate and Mineral Trioxide Aggregate (MTA). 135-second primary molars requiring pulpotomy treatment were selected from children between 3 and 6 years of age. All pulpotomized teeth were restored with amalgam. The subjects were monitored

periodically for 3 and 12 months. The clinical success rate of the MTA group was 82.1% after one year, which was significantly less than the 100% observed in the other groups (P= 0.005). The highest and lowest radiographic success rates after one year were encountered in the formocresol (92.5%) and MTA (69.2%) groups respectively, which showed a significant difference (P=0.01). The success rate of the ferric sulfate group was 80.50%. According to authors MTA is not recommended as a pulpotomy medicament in primary teeth, but ferric sulfate may be acceptable as an alternative to formocresol.

Percinoto, de Castro AM 2006[36] –compared clinical and radiographic examinations of calcium hydroxide and mineral trioxide aggregate (MTA) as pulpotomy medicament of primary molars. Ninety primary molars were selected. The pulpotomy were performed in two sessions, using a corticosteroid/antibiotic solution as therapeutic dressing. The samples were divided into two groups of 45 teeth, in which the pulpal remains were protected with either calcium hydroxide paste (Group 1) or MTA (Group 2). Radiographs were taken immediately and at 3-, 6-, and 12-month follow-up appointments. Three teeth in Group 1 failed after three months, while two cases failed after six months and one more failed at one year. Two failures were found in Group 2 at the 12-month follow-up. These results indicate that both materials may be utilized for pulpotomy in primary teeth.

PengL, Ye L 2006[35]-carried a evidenced based study using Medline, Cochrane Library, Embase, Science Citation Index, China National Knowledge

Infrastructure, reference lists, published literatures. Six studies met the inclusion criteria (giving a total of 381 teeth). Clinical assessments and radiographic findings of the MTA versus FC pulpotomy suggested that MTA was superior to FC in pulpotomy, resulting in a lower failure rate [relative risk, 0.32 (95% confidence interval, 0.11–0.90) and 0.31 (95% confidence interval, 0.13–0.74) respectively]. The results demonstrate that in primary molar teeth with vital pulp exposure caused by caries or trauma, a pulpotomy performed with MTA results in better clinically and radiographically observed outcomes. Fewer undesirable responses were recorded for MTA than when FC was used. The study supports the usage of MTA as a pulpotomy agent on primary molars.

Srinivasan V, Patchett Cl et al 2006[45]- the author states that International Agency for Research on Cancer has recently classified formaldehyde as carcinogenic to human beings. Since Buckley's Formocresol contains 19% formaldehyde in its full strength a safer alternative should be identified. After consideration of a review of extensively searched literature, a protocol and key points document have been developed by authors to assist clinicians in their treatment planning. Long-term studies with the highest level of evidence are suggested by authors to enable to identify acceptable alternatives for Formocresol.

Aeinehchi M, Dadvand S et al 2007[1]- compared the outcome of formocresol or mineral trioxide aggregate pulpotomy in primary molar teeth. 126 children (aged 5–9 years) with carious primary teeth that required pulpotomy were selected. Following randomization, a standard pulpotomy preparation was undertaken, and

the coronal pulp removed and bleeding arrested. In the FC group, cotton balls, soaked in FC, were placed for 5 min, and then the pulp chamber was filled with Zonalin, a pulpotomy agent. In the MTA group, a 1-mm-thick paste of MTA was used as a pulpotomy agent. The crowns in both groups were restored with amalgam or glass ionomer. The teeth of 100 patients were evaluated and compared clinically and radiographically after 3 and 6 months. No signs of clinical failure were observed at the 3- and 6-month follow-up appointments in either group. At the 6-month follow-up, significantly more cases ($P = 0.036$) with root resorption were seen in the FC group; no cases of resorption occurred amongst the MTA cases. The surrounding tissue showed radiographic signs of post-treatment disease in four FC cases; none was seen in the MTA cases. Thus after 6 months, pulpotomy with MTA was associated with fewer cases of root resorption and post-treatment disease. MTA appears to be a reliable alternative material for pulpotomy in primary molar teeth.

Materials & Methods

The study was conducted on children who had attended the out patient department of Pediatric and Preventive dentistry, Ragas dental college, Chennai with good general health and no history of systemic illness or hospitalization. The Ethical Committee in Human Research of the Institution approved the study. Participation in the study was voluntary and a written consent was obtained from the parents or guardians.

The study was performed on 100 mandibular molar teeth requiring pulpotomy treatment. Children between age four and six years of both the sexes were randomly selected and divided into Formocresol or MTA group. In case a child with two molars needed pulpotomy, the second tooth was assigned to the alternate group. In case more than two were present requiring for treatment, random assignment was used.

Histological assessment was done on lower deciduous canine teeth, which were undergoing serial extraction for interceptive orthodontic purpose. The teeth were divided into 2 groups. Pulpotomy was done on four teeth with Formocresol and another four teeth with MTA. The teeth were extracted after 6months following pulpotomy procedure and histologically evaluated. Two freshly extracted carious teeth were taken as control.

The following materials were used in the study:

- Local anesthetic-topical lignocaine hydrochloride jelly
- Lignocaine hydrochloride solution-1: 80,000 adrenaline solution-Lignox
- Disposable syringe with needle
- Rubber dam
- Dental floss
- Saline
- Spoon excavator.
- Condenser.
- Tweezer.
- No: 330 straight fissure bur, round bur #8, #10
- High speed hand piece with water coolant.
- Sterile cotton pellets.
- Diluted Formocresol. (20%v/v, Pharmadent remedies)
- Zinc oxide eugenol restorative material-Deepak enterprises Mumbai
- MTA -gray –product 8202- Angelus, Brazil
- Type 2 Glass ionomer cement-GC Fuji 2 corporation Tokyo
- Stainless steel crown-3M company
- Tapered fissure, flame shaped bur
- No: 417 crimping plier
- No: 114-Johnson contouring plier
- Rubber wheel/ green stone- for finishing and polishing

- Cement mixing spatula, glass slab
- Electronic digital caliper
- Luting cement-type I Glass ionomer cement-G. C Corporation Fuji 2-Tokyo.
- Articulating paper
- X-ray viewer
- Magnifying lens

The clinical criteria for tooth selection [48, 22]

1. Teeth with deep carious lesion (radiographically the caries should be approximating to the pulp).
2. Teeth should be restorable after completion of the procedure.
3. Absence of symptoms indicative of advanced pulpal inflammation such as spontaneous pain or history of nocturnal pain
4. Absence of clinical signs or symptoms suggesting a nonvital tooth such as suppurating sinus soft tissue swelling
5. Absence of clinical radiographic signs of pulpal necrosis i.e. furcation involvement, periapical pathology, internal resorption, calcification in canal.
6. Hemorrhage should stop within five minute from the amputated pulp stumps using a sterile pledget of moist cotton.

The study was done on lower right and left first and second molars for accessibility and accuracy. The pulpotomy procedure was then performed on the selected teeth as follows:

The tooth was anesthetized and rubber dam isolation obtained. Soft debris, caries and unsupported enamel and dentin were removed with spoon excavator before opening the pulp chamber. Caries removal and coronal access obtained with # 330 high-speed bur with water spray. Removal of the coronal pulp was done with a small sharp spoon excavator. Pulp chamber was then irrigated with saline to remove all debris. Hemostasis was obtained with a moistened cotton pellet gently pressed against the amputated pulp stumps in both the groups.

In formocresol (control) group - cotton pellet dipped and squeezed in diluted formocresol (Pharmadent Remedies-1/5th dilution of Buckley formocresol) was placed in pulp chamber for 1 minute. The pulp chamber was then covered with a Zinc oxide Eugenol thick mix. The coronal part was restored with type II glass ionomer cement (GC Fuji 2) followed by stainless crown placement. The crown was luted with Type1GIC (GC Fuji 1)

In the MTA (experimental) group - the MTA paste was obtained by mixing 3 parts of powder with 1 part of water to obtain a putty consistency based on manufacturer's instruction. This mix was then placed in the pulp chamber with aid of plastic filling instrument. A layer of Zinc oxide Eugenol thick mix was placed over MTA. The coronal part of the tooth was restored with type II glass

ionomer cement (GC Fuji 2) followed by stainless crown placement. The crown was luted with Type 1 GIC (GC Fuji 1).

The procedure for stainless steel crown placement is as follows. The stainless steel crown was selected based on the mesiodistal width of the tooth to be crowned using digital caliper. Occlusal reduction of 1.5-2 mm was done using flame shaped bur. 1mm depth grooves were placed initially to make reduction accurate. Using tapered fissure bur proximal reduction was done by moving the bur in bucco-lingual direction. Using a finishing bur all the line angles were rounded. The stainless steel crown was then trial fitted. The excess material was cut with curved crown scissors. The crown was then crimped at the gingival margin. The margins were finished with green stone. After isolation of teeth with cotton rolls the crown was cemented with type I glass ionomer cement (GC-Fuji-1). After cementation immediate postoperative radiograph were taken for future review.

The patients were recalled after 3month, 6months, 9months and 12 months respectively and evaluated clinically and radiographically. The radiographs were evaluated by two examiners at follow up who were blind to the group and a consensus was reached.

Teeth were considered to be clinically successful in the absence of [48, 22, 6]

- Spontaneous pain
- Draining fistula
- Swelling or abscess

- Mobility
- Premature exfoliation.

Teeth were considered to be radiographically successful in the absence of [48,22,6]

- Abnormal root resorption
- Internal root resorption.
- Furcation involvement
- Periapical bone destruction.

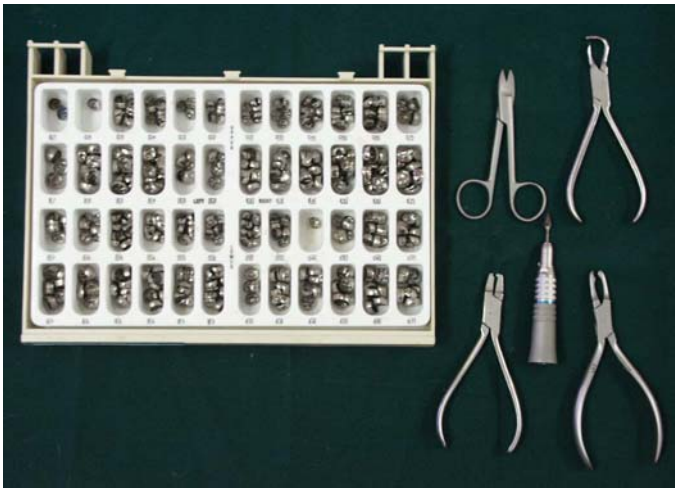
Pulp canal obliteration and pulp calcification was not regarded as a failure [2, 14]

Histological study was done with the help of Oral Pathology department, Ragas Dental College. The extracted teeth were all fixed in buffered formalin and decalcified in 3% trichloroacetic acid. Buccolingual sections were processed and prepared for microscopic examination under 4X, 10X, and 40X magnification. An examiner who was blind to the pulpotomy medicaments evaluated the slides. The histological features that were evaluated were odontoblastic integrity, pulp inflammation, pulp calcification, dentine bridge formation and presence of pulp stone.

Instruments used

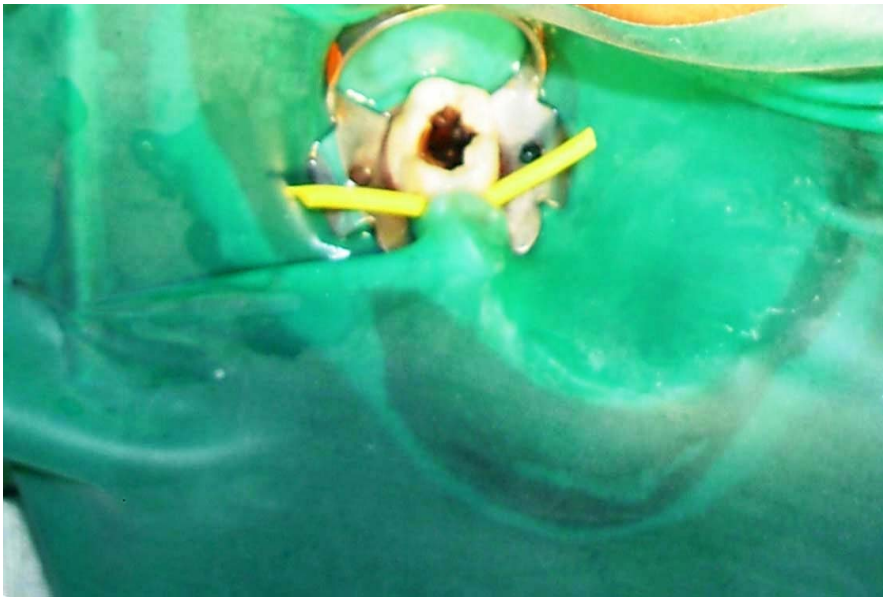
Materials used

Stainless steel crown armamentarium

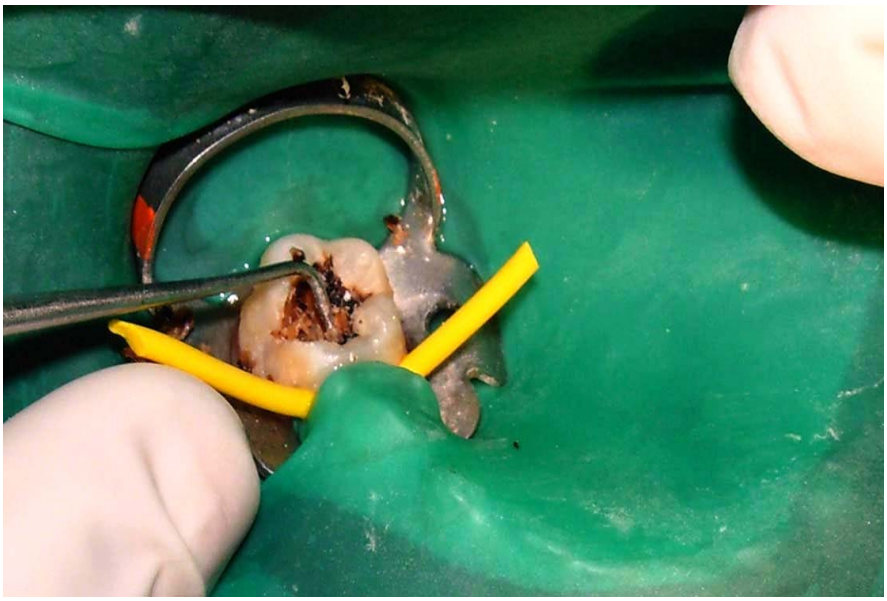


PULPOTOMY TECHNIQUE

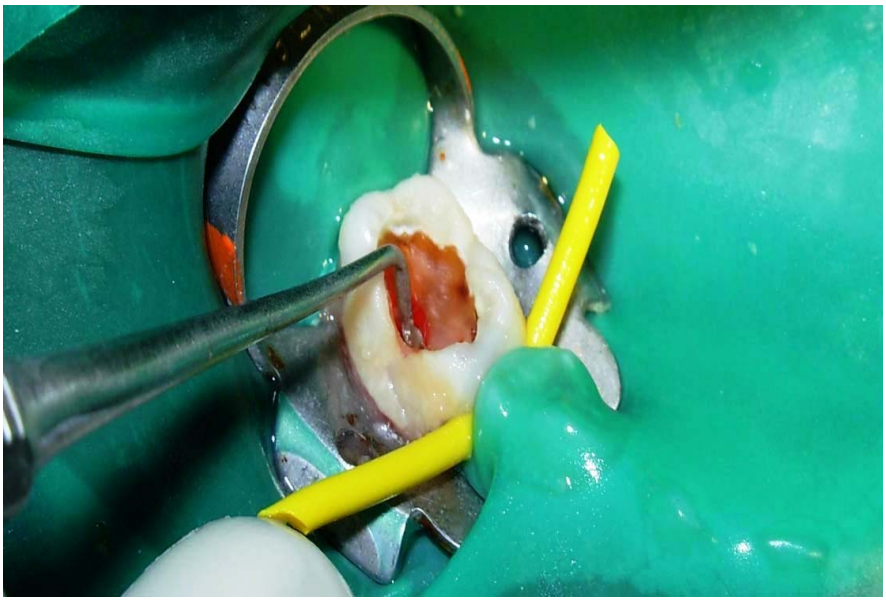
Prep - Op and Rubber Dam Isolation



Soft Debris and Unsupported Enamel Removed With Spoon Excavation

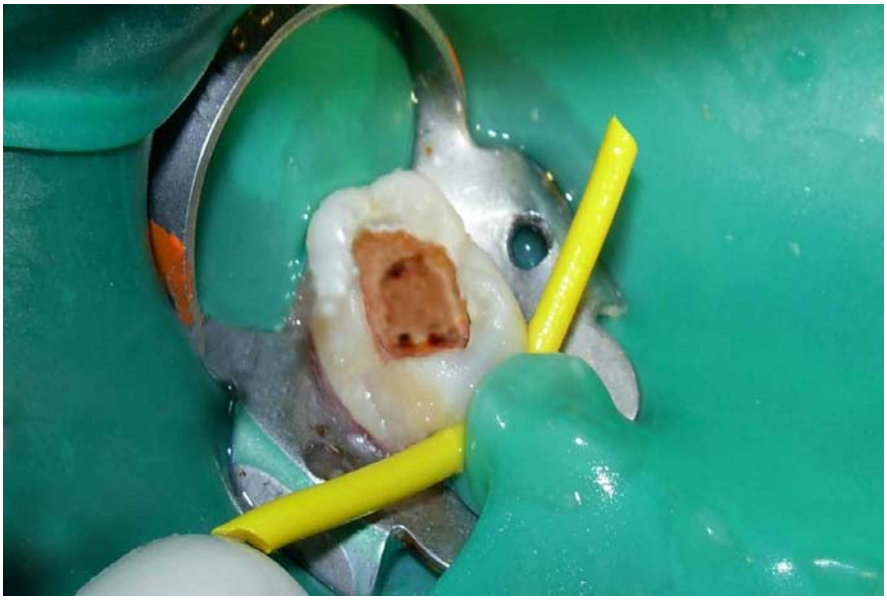


Roof of the Pulp Chamber Exposed

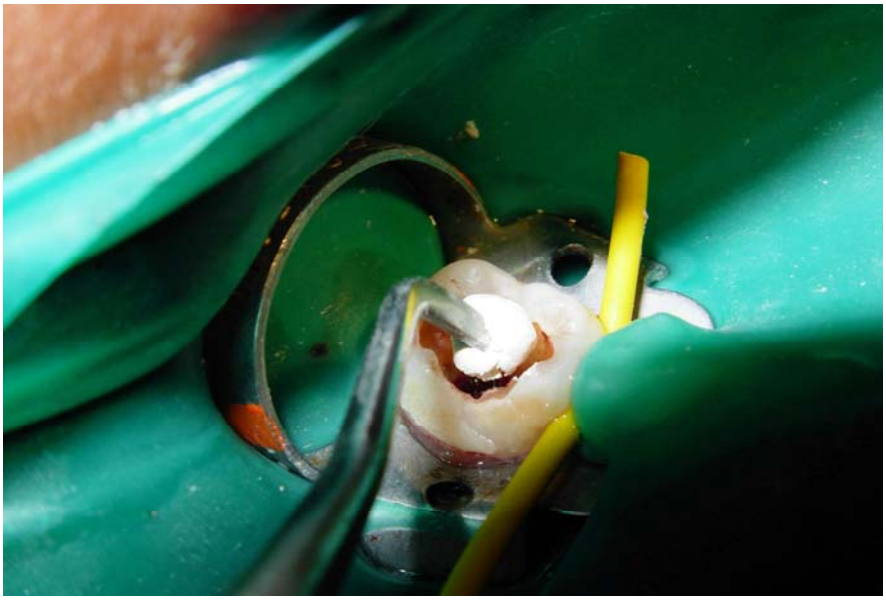


Sterile Cotton Pellet Placed For Hemostasis

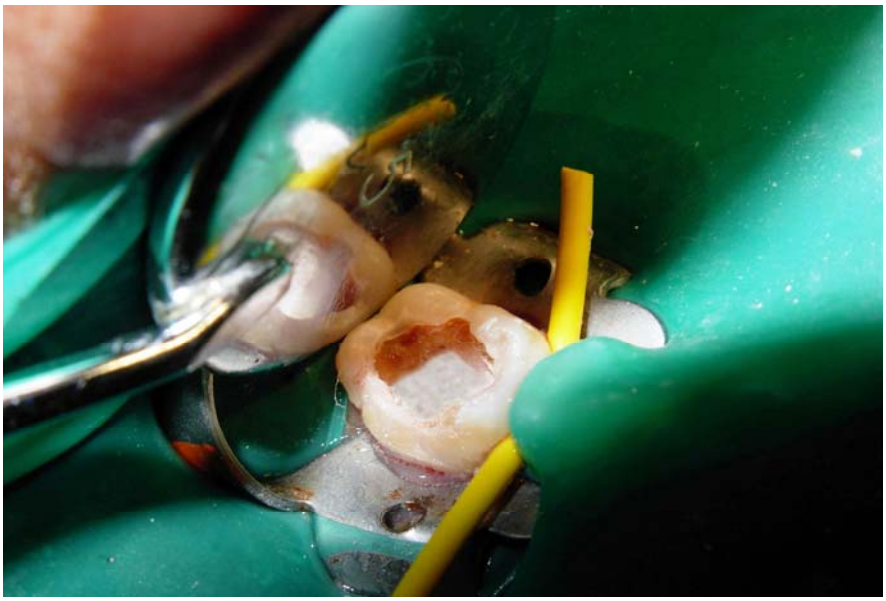
Pulpotomized Site after Placement of Formocresol



Placement of ZNOE over Formocresol Pulptomized Site



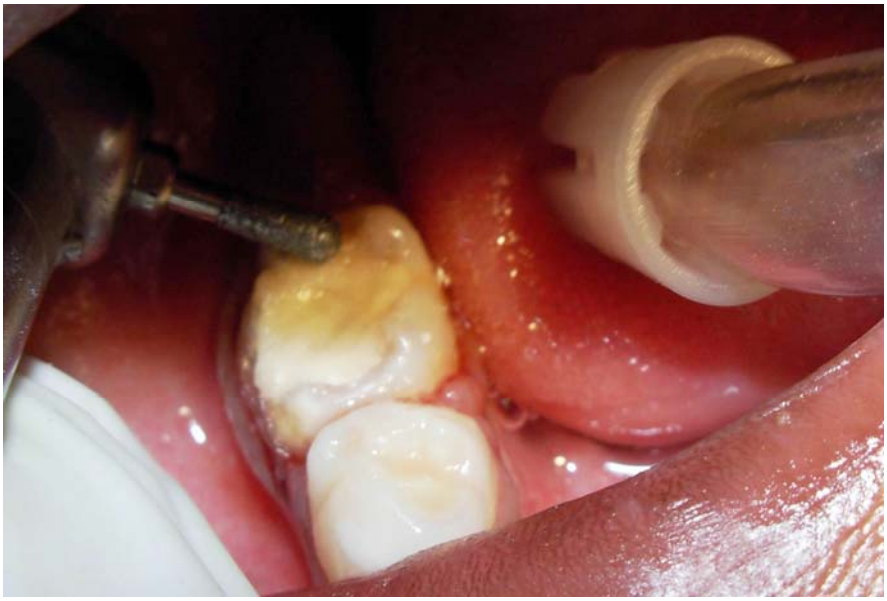
MTA Placed Immediately After Hemostasis Obtained with Cotton Pellet



GIC – Type II Placed as a Coronal Filling

CROWN PREPARATION FOR STAINLESS STEEL CROWN

Occlusal crown reduction



Proximal crown reduction

Completed crown preparation

Completed S.S. Crown in Occlusion

Observations & Results

The study was conducted on 63 children of 4-6 years age who were selected from the patients attending the Department of Pediatric and Preventive Dentistry, Ragas Dental College Chennai. 100 teeth requiring pulpotomy treatment in children between age four and six years of both the sexes were randomly selected and divided into two groups of 50 each, Formocresol and MTA group. After applying the pulpotomy medicament, Formocresol or MTA, the coronal part of both the group was restored with Zinc oxide Eugenol cement and Glass ionomer cement type 2. Stainless steel crown was placed on the same appointment. The teeth were evaluated at 3, 6, 9, 12-month intervals clinically and radiographically by two examiners who were blinded to study groups.

Table-1 represents distribution of sample. The teeth were lost to follow up because of transfer of parent's work to a different city. In Formocresol group 50 teeth were treated at the start of the study. Two teeth were lost to follow up at the end of 9 months and another two teeth were lost to follow up at end of 12 months. Thus, 46 teeth were evaluated clinically and radiographically at the end of 12 months. In MTA group, 50 teeth were treated at the start of the study. Three teeth were lost to follow up at end of 9 months. Thus there were totally 47 teeth for evaluation clinically and radiographically at end of 12 months.

Table-2 represents clinical evaluation of both the groups at 3, 6, 9, 12-month interval. The success criteria were taken as absence of pain, fistula, mobility, premature exfoliation of teeth. On 3, 6-month clinical evaluation, Formocresol group did not show any clinical signs and symptoms with the success rate of

100%. Four teeth showed grade –1mobility at 9 months .The success rate at end of 9 months was 91.6%. The same clinical symptoms were noted at 12 month in the same four teeth. Two teeth were lost to follow up with success rate of 91.3% clinically at end of 12 months. In MTA group no clinical signs and symptoms were noted from 3 to 12 months. The clinical success rate was 100%.

Table-3 represents radiographic evaluation of both the groups at 3, 6, 9, 12-month interval. The success criteria were taken as absence of abnormal root resorption, Inter radicular radiolucency, periodontal ligament widening, periapical radiolucency, and internal root resorption.

In radiographic evaluation no failure was noted in both the groups at 3 months interval. In 6-month evaluation five teeth in Formocresol group showed periodontal ligament widening, out of which two teeth had associated interradicular radiolucency. The radiographic success rate was, 90% with Formocresol at end of 6-month interval. In MTA group no failure was noted radiographically, success being 100% at end of 6 months.

At 9-month evaluation, in Formocresol group, additional four teeth had periodontal ligament widening, totally being 9 teeth, out of which five had associated interradicular radiolucency and one had associated abnormal root resorption. The radiographic success rate was 81.25% at the end of 9 months. In MTA group at 9-month evaluation two teeth had periodontal ligament widening. The radiographic success rate was 95.74%.

In 12-month interval, in Formocresol group, additional one tooth had periodontal ligament widening, totally being ten teeth, out of which seven had associated inter- radicular radiolucency and two teeth had associated abnormal root resorption. The success rate of Formocresol at end of 12 months was 78.26%. In MTA group at 12-month evaluation in the same two teeth as in previous evaluation, periodontal ligament widening was noted and out of which one of the teeth had additional inter radicular radiolucency. The radiographic success rate of MTA at end of 12 months was 95.74%.

The success rate at end of 12 months evaluation -

Clinically in Formocresol group	-	91.3%
Clinically in MTA group	-	100%
Radiographically in Formocresol group	-	78.26%
Radiographically in MTA group	-	95.74%
Overall success rate in Formocresol group		84.78%
Overall success rate In MTA group	-	97.87%

With the above results test of significance using Chi Square was carried out between the two groups. Statistically analysis revealed significant difference in mobility between two groups at end of 12 month ($p \leq 0.05$). Significant differences were noted radiographically with respect to periodontal ligament widening ($p \leq 0.01$ level) and inter - radicular radiolucency ($p \leq 0.02$ level) between two groups at end of 12 month. Other parameters were not significant between the two groups.

Pulp canal obliteration was noted with MTA at end of 12 months. A case of replacement resorption was noted with Formocresol at 12 month. Both pulp canal obliteration[2, 14] and replacement resorption were not considered as failure of treatment. Thus they were not included in statistical analysis of the study.

Histological evaluation:

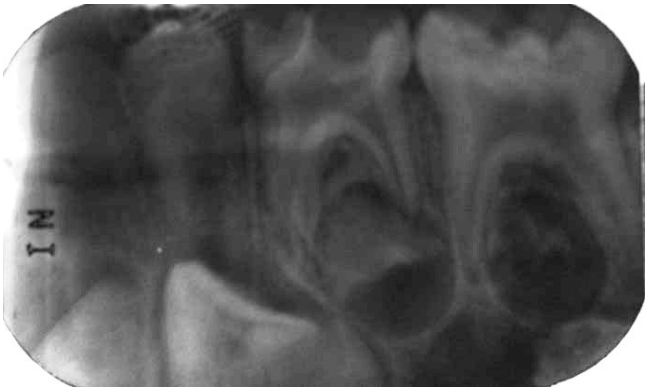
In Formocresol group, increased inflammatory cells were found in pulp. Odontoblastic layer was not intact throughout the dentine pulp complex. . Pulp stones were isolated and scattered. Pulp stones were less in number compared to MTA group. Dentine Bridge was not seen. A zone of atrophy was noted in radicular portion of pulp.

In MTA group, odontoblastic layer integrity was well maintained. Numerous pulp calcifications-pulp stones were seen. These calcific masses were found isolated. The amounts of pulp stones were more than Formocresol group. The pulp was hyperemic, yet less inflammatory cells were seen comparing Formocresol group. Reversal line/ resting line were noted. An amorphous eosinophilic layer of neo dentine formation with less dentinal tubules was seen in the coronal portion of pulp. This could be considered as Dentine Bridge, which represents the pulpotomized regenerating site.

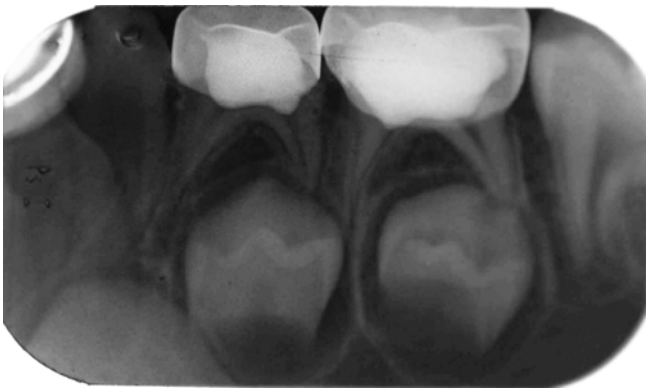
In control group in which freshly extracted teeth without placement of medicaments, complete atrophy of pulpal space was noted.

FORMOCRESOL PULPOTOMY

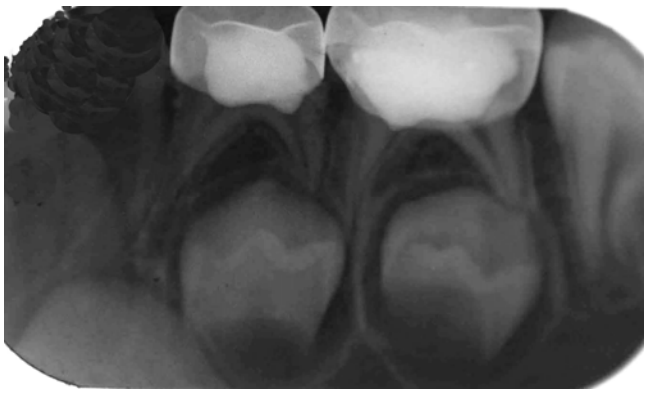
Pre-op



Immediate Post-Op

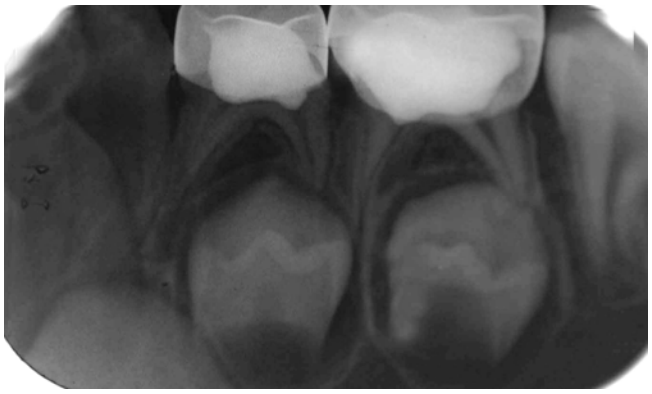


3-month



6-month

9-month

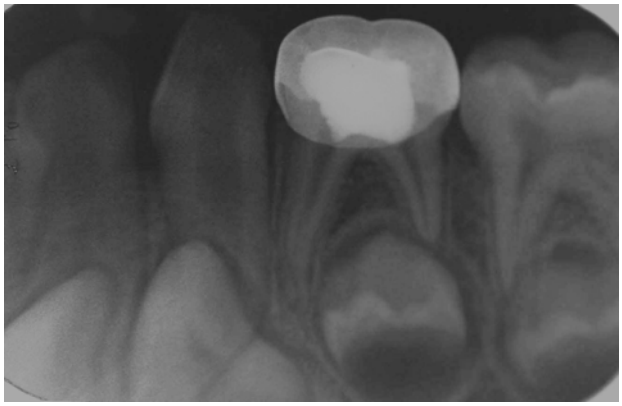


12-month

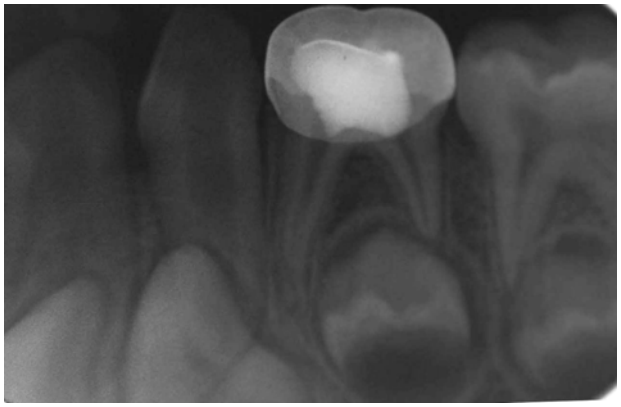
MTA PULPOTOMY

Pre-op

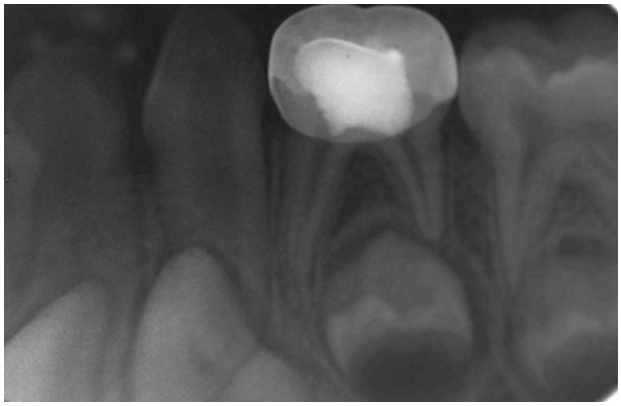
Immediate Post-Op



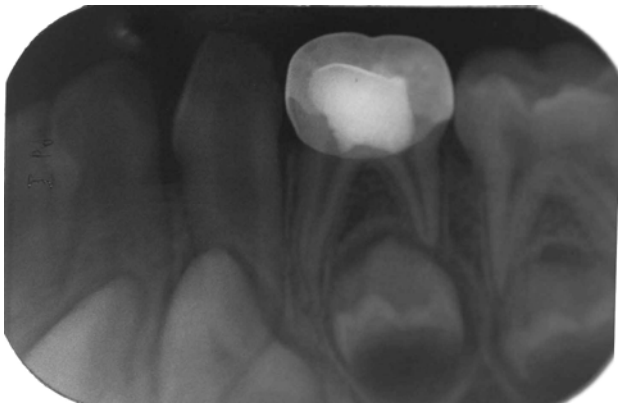
3-month



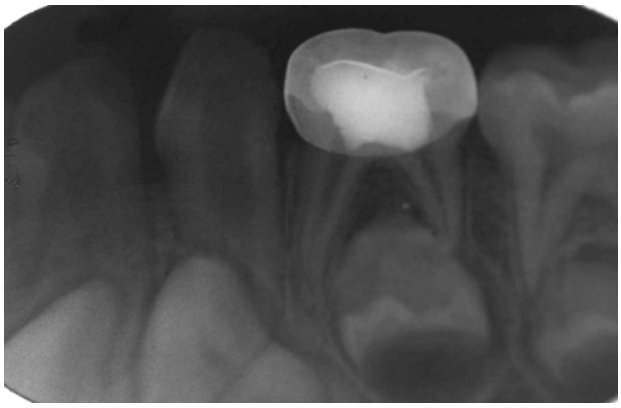
6-month



9-month



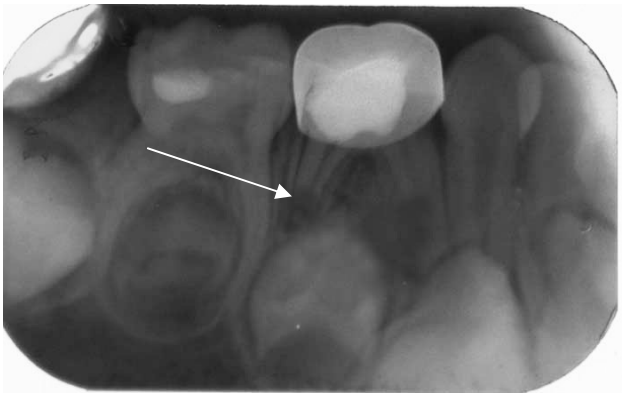
12-month



INCREASED ROOT RESORPTION

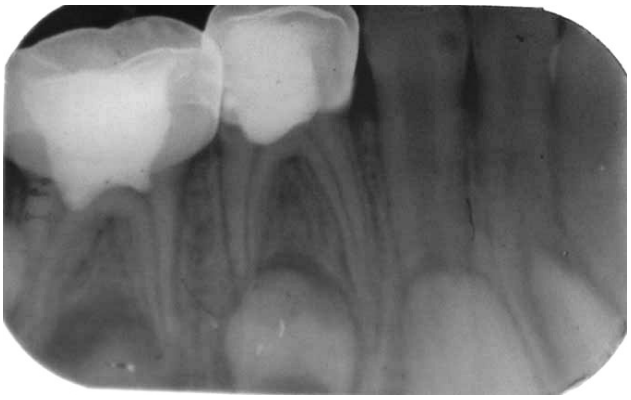
Base line (formocresol)

Post Op - 12 month



INTER RADICULAR RADIOLUCENCY

Base line (formocresol)

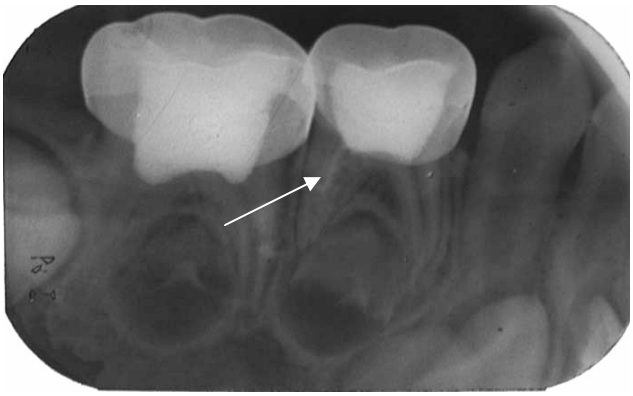


Post Op – 6 month

PULP CANAL OBLITERATION

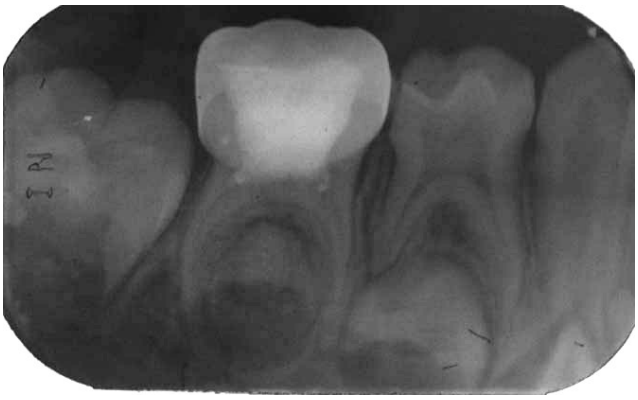
Base line (MTA)

Post Op - 12 month



PERIODONTAL LIGAMENT WIDENING

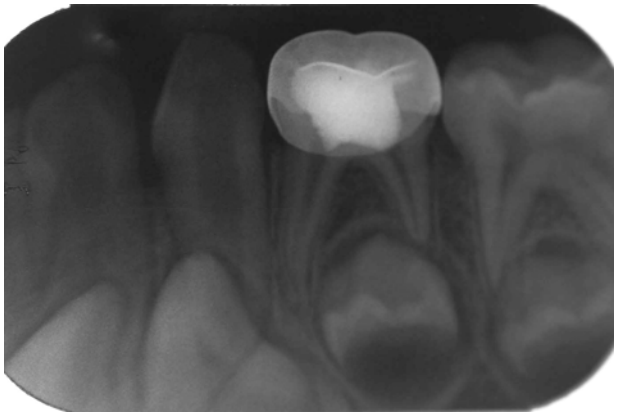
Base line (formocresol)



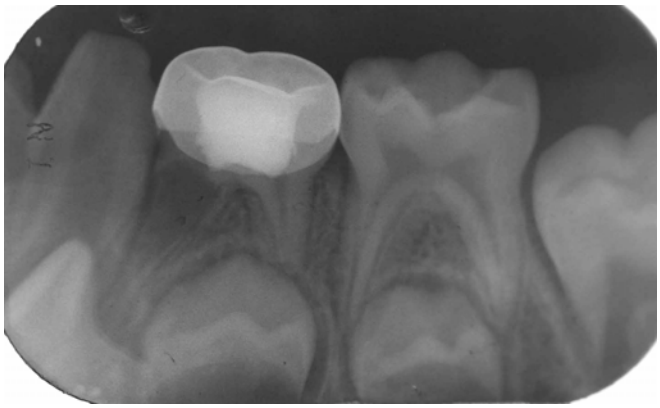
Post Op - 6 month

REPLACEMENT RESORPTION

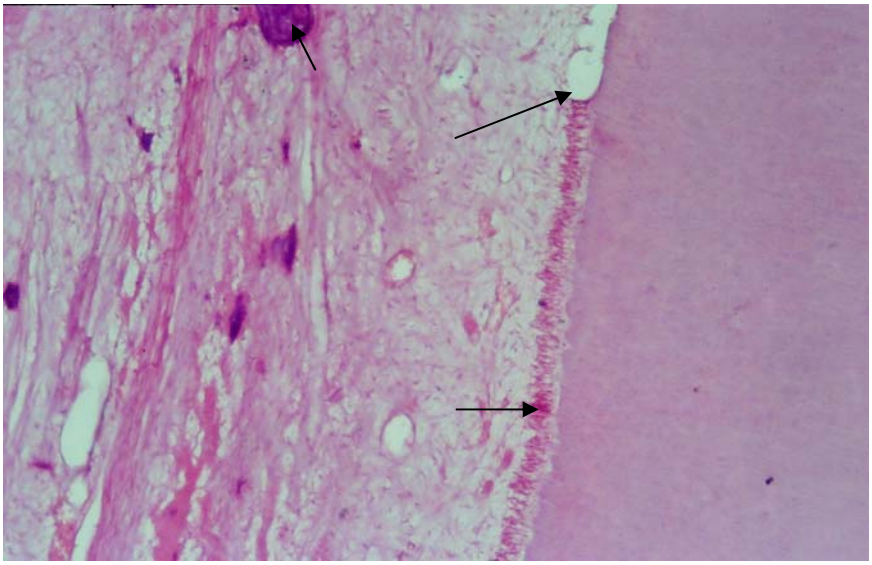
Base line (formocresol)



Post Op - 12 month

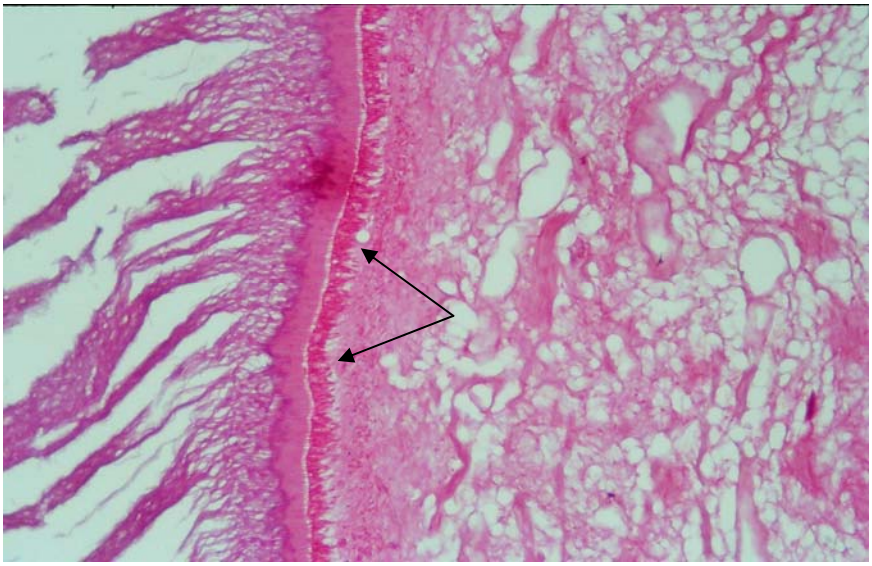


FORMOCRESOL (10X) - ODONTOBLAST, PULP STONE



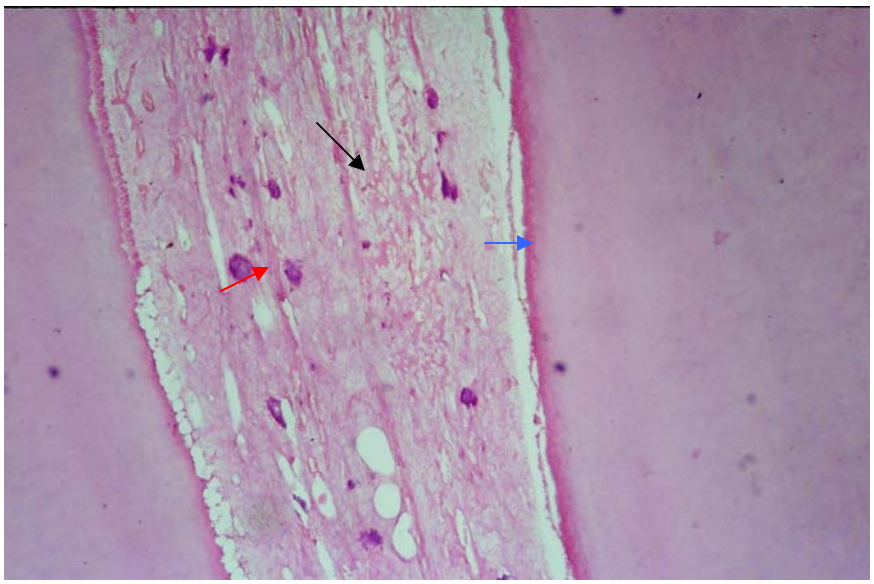
Integrity of odontoblast not maintained. Round hematoxilic masses are pulp stones

MTA (10X) - ODONTO BLASTIC LAYER MAINTAINED



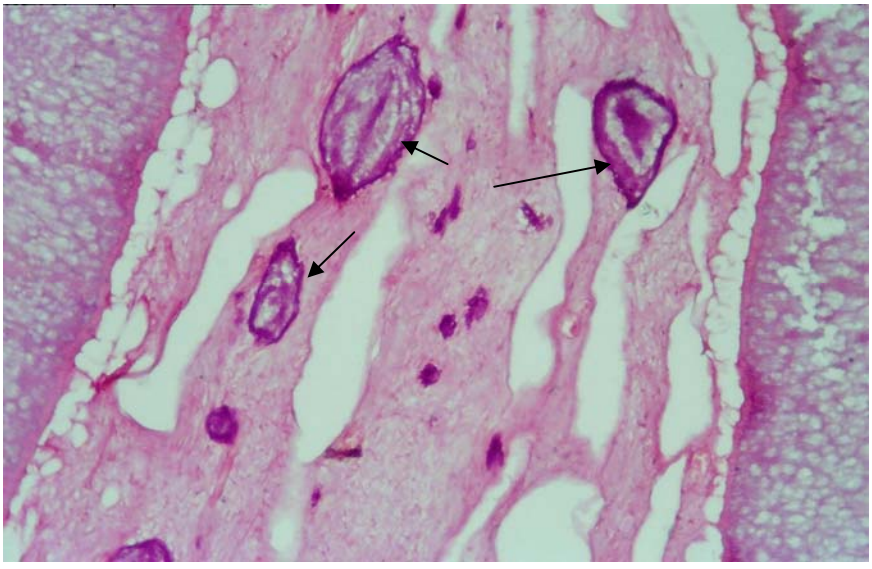
Integrity of odontobalst maintained throughout the dentine pulp complex.

FORMOCRESOL (4X) – Integrity of Odontoblast not maintained, Pulp stone seen, Pulp hyperemic



Integrity of odontoblast is not maintained throughout dentine pulp complex. Pulp stones are found as isolated discrete masses. Pulp is hyperemic with dilated blood vessels.

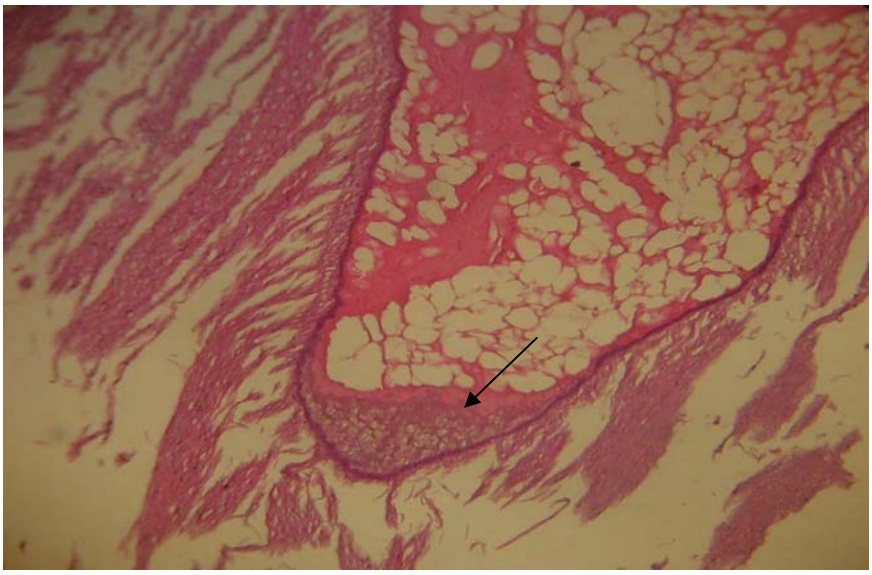
MTA - 10X PULP STONE



Pulp stones are large, discrete, isolated and more in number

FORMOCRESOL - NO EVIDENCE OF DENTINE BRIDGE

MTA - EVIDENCE OF DENTINE BRIDGE



PULP DEGENERATION - CONTROL TEETH

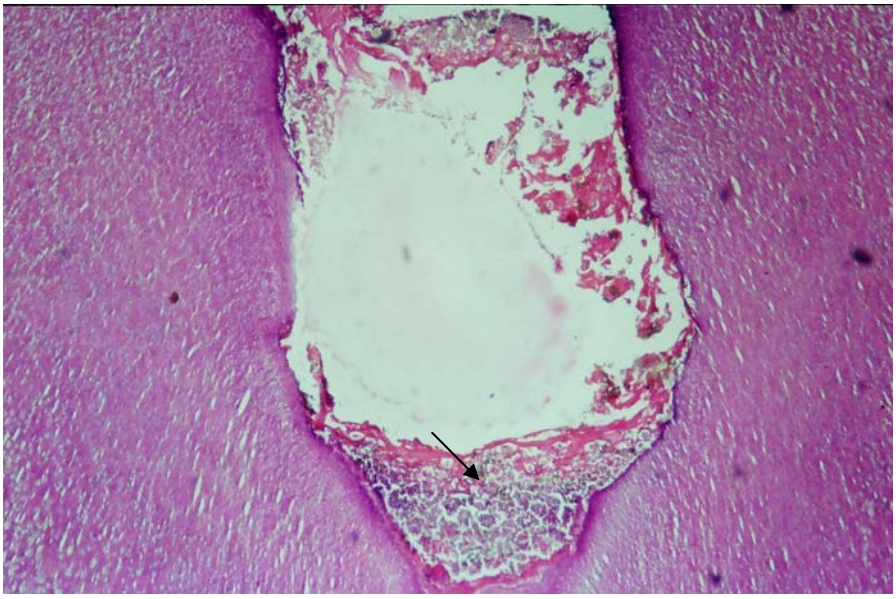


Table-1

DISTRIBUTION OF SAMPLE DURING THE STUDY

Evaluation	Formocresol			MTA		
Intervals	**Total**	**D**	**E**	**Total**	**D**	**E**
3month	50	30	20	50	27	23
6month	50	30	20	50	27	23
9month	48	28	20	47	25	22
12month	46	27	19	47	25	22

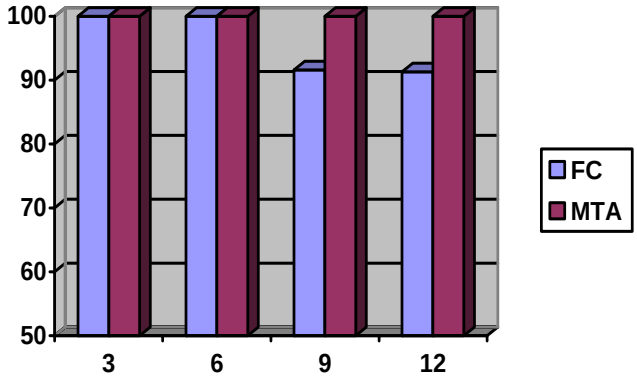
Table-2
CLINICAL EVALUATION
Values given in parenthesis are success percentage.

		3month	3month	6month	6month	9month	9month	12month	12month	P Value
		FC	MTA	FC	MTA	FC	MTA	FC	MTA	
Pain	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	
Fistula	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	
Abscess	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	
Mobility	Present	0	0	0	0	4	0	4	0	≤ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	44 (91.6%)	47 (100%)	42 (91.3%)	47 (100%)	
Premature Exfoliation	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	

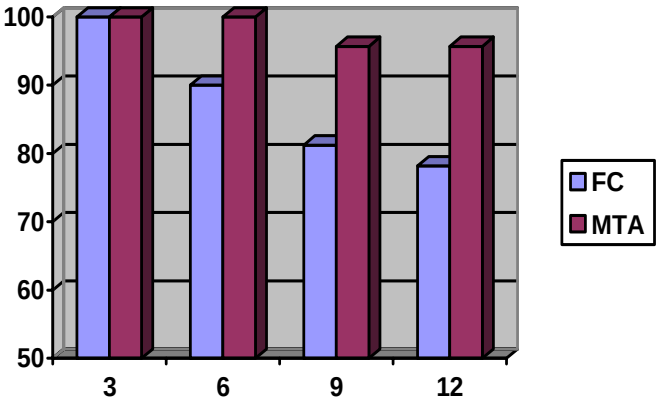
Table-3
Radiographic Evaluation
Values given in parenthesis are success percentage.

		3mont	3month	6month	6month	9month	9month	12month	12month	P Value
		FC	**MTA**	**FC**	**MTA**	**FC**	**MTA**	**FC**	**MTA**	
Abnormal root resorption	Present	0	0	0	0	1	0	2	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	47 (97.9%)	47 (100%)	44 (95.6%)	47 (100%)	
Inter radicular radioluscency	Present	0	0	2	0	5	0	7	1	≤ 0.02
	Absent	50 (100%)	50 (100%)	48 (96%)	50 (100%)	43 (89.5%)	47 (100%)	39 (84.78%)	46 (97.8%)	
Periodontal ligament widening	Present	0	0	5	0	9	2	10	2	≤0.01
	Absent	50 (100%)	50 (100%)	45 (90%)	50 (100%)	39 (81.25%)	45 (95.7%)	36 (78.2%)	45 (95.7%)	
Periapical Radioluscency	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	
Internal Root resorption	Present	0	0	0	0	0	0	0	0	≥ 0.05
	Absent	50 (100%)	50 (100%)	50 (100%)	50 (100%)	48 (100%)	47 (100%)	46 (100%)	47 (100%)	

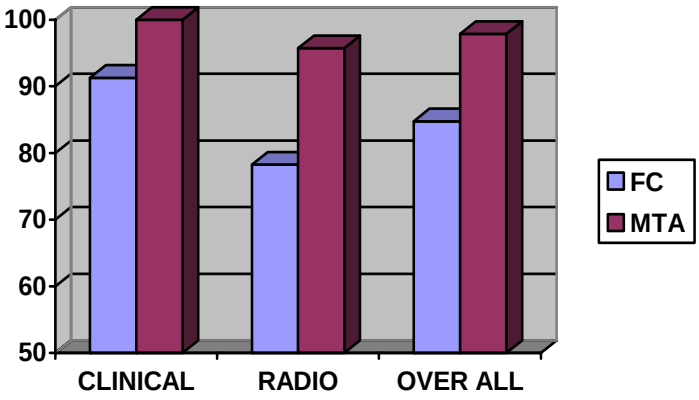
Clinical Comparison of Success Rate between Formocresol and MTA at 3 Month Intervals



Radiographic Comparison of Success Rate between Formocresol and MTA at 3 Month Intervals



Success Rate between Formocresol and MTA at the end of 12 Month



Discussion

The study was conducted on 63 children who were selected from among the patients attending the Department of Pediatric and Preventive Dentistry, Ragas Dental College Chennai. 100 teeth requiring pulpotomy treatment in children between ages four and six years of both the sexes were randomly selected to either of the group, Formocresol or MTA group.

Preservation of primary and young permanent teeth remains one of the main challenges of a pediatric dentist. Premature loss of primary teeth leads to space loss, causing deficiency of arch length. Other objectives being, to maintain the integrity of primary dentition, to prevent aberrant tongue habits, mastication, esthetics and occlusion. Pulpal therapy is one of the ways in which pulpally exposed teeth due to caries or trauma can be saved. Among the various procedures pulpotomy has gained wider acceptance.

Formocresol usage has been criticized because of the following reports. Addition of cresol to formaldehyde caused cytotoxic effects and proved to be 40 times more toxic than cresol (Jeng HW, Feigal 1987). Formocresol has been demonstrated diffusing into pulp, dentin, periodontal ligament, cementum and bone surrounding the apexes of pulpotomized teeth (Cwikla 1972) [36]. There is fear of damage to the succedaneous tooth, enamel defects on the permanent successors [30], positional alterations of the underlying permanent tooth bud (Rolling I, Poulsen S 1978), necrosis of crestal bone and overlying gingival tissue (Cambruzzi and Greenfield 1983) and necrosis of crestal bone due to the usage of formocresol in permanent teeth (Kawaikami et al 2003), premature exfoliation of

primary molar [18] have been reported. . They could inhibit macrophage function and modulate immune and inflammatory responses in dental pulp and periapical tissues. Kidney is the most vulnerable organ to damage from formaldehyde [36].Mutagenicity has been demonstrated in studies on Drosophila (Kaplan 1948), Escherichia coli (Nishioka 1973), Neurospora (Jenson et al. 1951). There have also been reports that exposure of formaldehyde leads to unstable DNA-protein links which can cause clastogenic lesions, sister chromatid changes, chromosomal aberrations. The International Agency for Research on Cancer (IARC) of the World Health Organization in June 2004 stated that there was sufficient evidence that formaldehyde causes nasopharyngeal cancer, limited evidence that it causes nasal and paranasal sinus carcinoma and strong but not sufficient evidence that formaldehyde causes leukemia in humans. Buckley's formocresol was mutagenic for one patient in an in vivo study to lymphocyte cultures obtained from the peripheral blood [50], raising doubt about the desirability of its use for pulpotomies in children.

There are also reports stating that amount of Formocresol usage is safe. Formaldehyde is found in the air we breathe, the water we drink and the food we eat. Although daily intake from food is difficult to evaluate, the World Health Organization has estimated it at 1.5-to 14-mg/ day (mean 7.8 mg/day). The estimated dose of formaldehyde associated with one pulpotomy procedure, assuming a 1:5 dilution of formocresol placed on a number 4 cotton pellets that has been squeezed dry, is 0.02 to 0.1 mg. Thus there is no inconsequential risk of carcinogenesis associated with formaldehyde use in pediatric pulp therapy

[31].Formocresol was selected as the control group, since it is still considered the gold standard in primary tooth pulp therapy. The 1minute application of Formocresol is found to be as effective as 5 minutes (Garcia Godoy 1982). Results of the various studies (Loos &Hans 1971, Morawa 1974, Straffon L.H) have found that 1: 5 dilution (20% concentration) achieves desired cellular response and faster recovery of the affected cells. Thus in the present study diluted Formocresol at 20% dilution (pharmadent laboratories) at 1 minute application was followed. The British Society of Paediatric Dentistry guidelines 2006, when describing the procedure for a pulpotomy, suggest that one of the medicaments that can be chosen is a 1 in 5 dilution of Buckley's FC solution although they do add that routine use of the FC pulpotomy "may be imprudent given the availability of effective alternatives".

The need for search for newer medicaments led to usage of Mineral tri oxide aggregate as a pulpotomy agent as introduced by Torabinejad M 1993. Its main components are tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide. Bismuth oxide also has been found in MTA, which gives the material radiopaque characteristics [7]. It is available as gray and white. Gray differs with the presence of ferrous aluminium silicate. Torabinejad et al mixed MTA with water and reported that the material's pH rose within three hours (from 10.2 to 12.5), showing evidence of an antimicrobial effect on some facultative anaerobic bacteria, due to the highly alkaline pH[16].

The mechanism of action of MTA is similar to that of calcium hydroxide and Portland cement [42]. Calcium oxide, one of its components, is converted into calcium hydroxide when the paste is mixed with water. This in turn dissociates itself into Ca and OH ions upon contact with the tissue fluids. The calcium ions react with the carbon dioxide in the tissues, producing calcite granulations. Fibronectin accumulates with these granulations, which allows cellular adhesion and differentiation to occur. A hard tissue bridge formation result [16, 17]. The MTA meets available currently in the market under the corporate names of MTA ProRoot® (Dentsply) and MTA-Angelus® (Angelus). The brands of MTA evaluated do not interfere in the cytokine response by M1 or M2 macrophages of the bacteria tested [39]. In the present study MTA Angelus was used.

The purpose of the study is to evaluate and compare MTA and Formocresol as a pulpotomy medicament by clinical and radio graphic assessment and to assess the histological features of MTA and Formocresol as pulpotomy medicaments.

The study was done on mandibular molar for accessibility and accuracy .The selection is based on criteria by previous studies [48, 22]. In Formocresol group, 1-minute application of 20% dilution was used. In MTA group medicament was placed on the pulp chamber based on the manufacture's instruction. Following pulpotomy all the teeth in the present study were restored with stainless steel crown on the same appointment. In a retrospective study comparing the success rates of formocresol pulpotomy in primary molars restored with stainless steel crowns (SSC) to those restored with amalgam (AM) [15], found pulpotomized

primary molars restored with SSC had more success [13]. Postoperative radiograph was taken on the same appointment as a reference. The patients were recalled after 3, 6,9,12 months intervals. Two examiners clinically and radiographically evaluated the teeth. The evaluation is based on the criteria of previous studies [48, 22, 6]

The clinical success criteria were taken as absence of pain, fistula, mobility, premature exfoliation of teeth. On 3, 6-month clinical evaluation, Formocresol group did not show any clinical signs and symptoms with the success rate of 100%. Four teeth showed grade –1mobility at 9 months .The success rate at end of 9 months was 91.6%. The same clinical symptoms were noted at 12 month in the same four teeth. Two teeth were lost to follow up at the end of 12-month review; the clinical success rate was 91.3%. The probable reason of failure may be due to reversible fixative effect of formocresol, and irritative pH, chemical and physical effects of ZOE on pulp tissue, which might have caused grade-1 mobility in Formocresol group. In MTA group no clinical signs and symptoms were noted from 3 to 12 months. The clinical success rate was 100%.

The radiographic success criteria were taken as absence of abnormal root resorption, Inter radicular radiolucency, periodontal ligament widening, periapical radioluscency, and internal root resorption. In radiographic evaluation no failure was noted in both the groups at 3 months interval, success rate was 100% for both the groups. The radiographic success at end of 6-month interval was 90% for Formocresol and 100% for MTA. . The radiographic success rate at end of 9

month was 81.25% for Formocresol, 95.74% for MTA. In 12-month interval, success rate of Formocresol was 78.26% and 95.74% for MTA. The common radiographic failure in the present study in formocresol group was periodontal ligament widening and inter radicular radioluscency. The probable reason may be due to fixative effect of formocresol, ability of vapours to escape via apical foramen, periodontal ligament, cementum, alveolar bone [36, 18] (Cwikla 1972). The radiographic finding of periodontal ligament widening and inter radicular radioluscency seen in two cases of MTA as failure can be attributed to misdiagnosis of inflammation in the radicular pulp prior to treatment [14]. Yet the teeth did not show any clinical signs of failure. These findings are comparable with other studies[6, 36].

The greater success rate of MTA is observed in the present study when compared to Formocresol pulpotomy clinically (MTA group 100% vs. 91.3%of Formocresol), radiographically (MTA group 95.74% vs. 78.26% Formocresol group) and overall (MTA group 97.87% vs. 84.78% Formocresol group). Significant difference in mobility between two groups at end of 12 month (p=0.05), and radiographically with respect to periodontal ligament widening (p=0.01 level) and inter radicular radioluscency (p=0.02 level) between two groups at end of 12 month were observed. This can be attributed to biocompatibility, and sealing ability of MTA cement [3] compared to Formocresol. In vitro toxicity of primary teeth pulpotomy agents based on MTT cell proliferation test and Neutral Red uptake colorimetric assays has ranked as: Formocresol>diluted Formocresol >ferric sulfate>calcium hydroxide>MTA.

MTA was the less cytotoxic pulpotomy agent. [28]. Thus MTA is a biocompatible material, which promotes hard tissue formation.

The results of the study are comparable to Eidelmann et al 2005 [14] [97% success for MTA (1 failure) and 83% for FC (5 failures], S.E. Jabbarifar 2004 [21] [93.75 % success rate for MTA and 90.6 % in FC group after one year], Aeinehchi et al M 2007 [1][fewer cases of root resorption and post-treatment disease in MTA group]. The results of the present study done with MTA angelus closely coincide with previous studies done with MTA, Dentsply, Tulsa Dental, and Tulsa [14, 40,2, 21,12,26,32]. The result of study does not agree with H. Neamatollahi [33] study where radiographic success of MTA pulpotomy was poorer 69.2% when compared to Formocresol 92.5%. This could possibly because of a smaller sample size (15 cases) or the wider age range of the patients (5 to 12 years), which can reduce the validity, and reliability of the results in their study.

Formocresol has been undergoing a process of rejection for several decades but there is still controversy over recommendations for its use. The recent Scottish Intercollegiate Guidelines Network guideline 2005 recommended that FC "should be replaced by alternative materials for pulpotomy procedures in primary teeth". In meta analysis of studies of Formocresol versus MTA, Peng L et al 2006 [35] suggested that MTA was superior to FC in pulpotomy, clinically and radiographically resulting in a lower failure rate [relative risk, 0.32 (95% confidence interval, 0.11–0.90) and 0.31 (95% confidence interval, 0.13–0.74) respectively].

Pulp canal obliteration as a result of odontoblastic activity suggests that tooth is retaining its vitality and therefore is not regarded as failure [14, 2]. An unusual single case of replacement resorption was noted with Formocresol at the end of 12 month. Replacement resorption was not taken as failure because it's also an accelerated odontoblastic activity.

Histologically the sections were examined for inflammation, odontoblastic layer integrity, pulp calcifications, dentine bridge formation. Histological examination of Formocresol showed increased number of inflammatory cells when compared to MTA, a zone of atrophy at the radicular portion with no dentine bridge formation, which confirms that formocresol, has no reparative ability and its action limited as a fixative agent. Histological examination of MTA section showed dentine bridge formation with more of neo dentine like tissue with less number of dentinal tubules. This zone was found at the coronal pulpotomy site where the medicament was placed indicating regenerative nature of the material. In vitro investigation has demonstrated the ability of MTA to stimulate cytokine release from bone cells, indicating that it actively promotes hard tissue formation rather than being inert [42] (Koh ET, Pitt Ford TR 1995, N.K Sarkar-IADR 2002.). Mineral trioxide aggregate maintains the integrity of the pulp [10]. Odontoblastic layer integrity was well maintained and was regular throughout the pulp dentine complex. Pulp calcifications were found in large numbers. Odontoblastic layer integrity and pulp calcification findings are consistent with Agamy etal, Caicedo study [2, 6] .The pulp inflammation in MTA group was similar to Chacko findings [9].

Dentine bridges formed could be as a result of pulp irritation and/or inflammation, or alternatively due to a stimulus from the material placed over the exposed pulp. Histological studies done in dogs, cats and rabbits, have also demonstrated hard tissue formation after placement of MTA [27, 29, 38,47,3]

In the present study in MTA slides large number of discrete calcification were seen suggesting a close relation between nerve fibers and odontoblastic cell differentiation suggesting repair of pulpotomized site which is similar to Inoue H study[20] where close contact between fibroblast-like cells/osteoblast-like cells and nerve terminals at the calcification front in the early healing process after calcium hydroxide pulpotomy was observed.

In the present study an evaluation criteria could not be done for histological assessment because of the smaller sample size and difficulty in getting extracted teeth after successful pulpotomy.

In the present study MTA has grater success rate at end of 12 months [clinically (100% MTA vs. 91.3%Formocresol), radiographically (95.74% MTA vs. 78.26% Formocresol) and Overall (97.87%MTA vs. 84.78%)] when compared to formocresol. The study is limited to a 12-month review and it requires complete follow up till the eruption of sucedaneous tooth.

Summary & Conclusion

This in vivo study was carried out on 100 deciduous mandibular molar found in 63 children aged 4 to 6 years .The aim of the study was to evaluate and compare MTA and Formocresol as a pulpotomy medicament by clinical and radio graphic assessment and to assess the histological features of MTA and Formocresol as a pulpotomy medicament. The study was carried out with evaluation done clinically and radiographically at 3, 6, 9, 12-month intervals.

Significant difference in mobility ($p \leq 0.05$), Periodontal ligament widening ($p \leq 0.01$ level) and inter - radicular radioluscency ($p \leq 0.02$ level) were seen between two groups at end of 12 month. Other parameters were not statistically significant between the two groups.

Histological examination done in deciduous mandibular canine showed dentine bridge formation in MTA sections following 6 months after pulpotomy. The integrity of odontoblast was well maintained and numerous pulp calcifications were found. These findings confirm the reparative ability of MTA.

The following conclusions can be drawn from the present study.

- MTA is superior to Formocresol clinically
- MTA is superior to Formocresol radiographically
- Histological analysis showed better reparative ability with hard tissue barrier formation with MTA compared to Formocresol.

Thus it can be concluded that MTA has biological characteristics to be used as pulpotomy medicament in deciduous teeth.

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Annexure

Annexure I: Ethics Committee Approval

The institutional review board Consisting of Chairman, Dr.S.Ramachandran, Members of board -Heads of all the Department, Advocate Mr. Kamalakannan, Social worker Mr. KK Raman, General Medicine - Dr. U V Ramakrishnan MD and General Surgery - Dr. Parthasarathy MS have approved the study titled *Comparative Evaluation of Formocresol and Mineral Trioxide Aggregate as a Pulpotomy Agent*.

Ragas Dental College and Hospital, Chennai

Department of Pedodontia and Preventive Dentistry

As per oral examination of your child's teeth, he/she requires pulp treatment with Formocresol/MTA for badly decayed teeth, which will be performed on chair side under Local Anesthesia and would require intra oral periapical radiograph for the same. The child will be followed at a regular recall once in 3 months, which requires your kind cooperation.

Ragas Dental College and Hospital.

Informed consent

I. ……Father/mother of master/miss……..

Herewith grant permission to participate in the above-mentioned study. I voluntarily give my consent to do the treatment.

Signature& name

Date

Place.

RAGAS DENTAL COLLEGE & HOSPITAL
UTHANDI. CHENNAI

உங்கள் குழந்தையின் பற்களை பரிசோதனை செய்ததில், மிகவும் சேதமான பற்களைச் சீர்செய்ய வேர் சிகிச்சை, ஃபார்மோகிரசால் / எம்.டி.ஏ தேவைபடுகிறது. இந்த சிகிச்சைக்கு வாயில் மறத்துபோக ஊசி கொடுப்பதும், வாயில் நிழல்படம் எடுப்பதுவும் தேவைபடுகிறது. மேற்படி சிகிச்சைக்கு அனுமதியும், ஒவ்வொரு மூன்றுமாத முடிவிலும் தங்கள் குழந்தையை ஆய்விற்காக அழைத்துவந்து ஒத்துழைப்பும் தரவேண்டும்.

ராகாஸ் பல் மருத்துவமனை மற்றும் கல்லூரி

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ஒப்புதல் படிவம்

செல்வன்/செல்வி _____ தந்தையாகிய/தாயாகிய

நான் _____ மேற்கண்ட சிகிச்சை என்னுடைய குழந்தைக்கு அளிக்க என் விருப்பத்தின்படி ஒப்புக்கொள்கிறேன். குழந்தையை ஒவ்வொரு மூன்றுமாத இறுதியிலும் ஆய்விற்காக அழைத்து வருவேன் என்றும் உறுதி கூறுகிறேன்.

இடம் :- பெயர் :-

தேதி :- கையொப்பம் :-

PROFORMA

Name of the child

Age Sex Date of birth

Parents Name

Address

Phone number

Chief complaint

History of Present illness

Past medical history

Past dental History

Parental dental History

Diet Diary

Extra oral examination:

Inspection-

Palpation

Swelling/ ulcer

Lymph node

TMJ

Intra oral Examination

Soft tissue examination-lip
Buccal Mucosa
Floor of mouth
Frenum
Tongue
Alveolar mucosa

Hard tissue examination

Teeth — Decay
Missing
Filling

Calculus/ stain

Occlusion

Provisional Diagnosis

Investigations- Radiographs-Intra Oral periapical radiograph

Treatment Plan

Master Chart
3 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
1	FC	84	N	N	N	N	N	N	N	N	N	26	FC	74	N	N	N	N	N	N	N	N	N
2	FC	75	N	N	N	N	N	N	N	N	N	27	FC	84	N	N	N	N	N	N	N	N	N
3	FC	74	N	N	N	N	N	N	N	N	N	28	FC	85	N	N	N	N	N	N	N	N	N
4	FC	84	N	N	N	N	N	N	N	N	N	29	FC	74	N	N	N	N	N	N	N	N	N
5	FC	85	N	N	N	N	N	N	N	N	N	30	FC	75	N	N	N	N	N	N	N	N	N
6	FC	74	N	N	N	N	N	N	N	N	N	31	FC	74	N	N	N	N	N	N	N	N	N
7	FC	84	N	N	N	N	N	N	N	N	N	32	FC	84	N	N	N	N	N	N	N	N	N
8	FC	85	N	N	N	N	N	N	N	N	N	33	FC	85	N	N	N	N	N	N	N	N	N
9	FC	74	N	N	N	N	N	N	N	N	N	34	FC	84	N	N	N	N	N	N	N	N	N
10	FC	75	N	N	N	N	N	N	N	N	N	35	FC	85	N	N	N	N	N	N	N	N	N
11	FC	74	N	N	N	N	N	N	N	N	N	36	FC	84	N	N	N	N	N	N	N	N	N
12	FC	74	N	N	N	N	N	N	N	N	N	37	FC	75	N	N	N	N	N	N	N	N	N
13	FC	85	N	N	N	N	N	N	N	N	N	38	FC	74	N	N	N	N	N	N	N	N	N
14	FC	84	N	N	N	N	N	N	N	N	N	39	FC	85	N	N	N	N	N	N	N	N	N
15	FC	74	N	N	N	N	N	N	N	N	N	40	FC	74	N	N	N	N	N	N	N	N	N
16	FC	75	N	N	N	N	N	N	N	N	N	41	FC	84	N	N	N	N	N	N	N	N	N
17	FC	74	N	N	N	N	N	N	N	N	N	42	FC	85	N	N	N	N	N	N	N	N	N
18	FC	85	N	N	N	N	N	N	N	N	N	43	FC	74	N	N	N	N	N	N	N	N	N
19	FC	84	N	N	N	N	N	N	N	N	N	44	FC	84	N	N	N	N	N	N	N	N	N
20	FC	74	N	N	N	N	N	N	N	N	N	45	FC	75	N	N	N	N	N	N	N	N	N
21	FC	85	N	N	N	N	N	N	N	N	N	46	FC	74	N	N	N	N	N	N	N	N	N
22	FC	84	N	N	N	N	N	N	N	N	N	47	FC	84	N	N	N	N	N	N	N	N	N
23	FC	85	N	N	N	N	N	N	N	N	N	48	FC	75	N	N	N	N	N	N	N	N	N
24	FC	75	N	N	N	N	N	N	N	N	N	49	FC	85	N	N	N	N	N	N	N	N	N
25	FC	84	N	N	N	N	N	N	N	N	N	50	FC	84	N	N	N	N	N	N	N	N	N

C1 - Pain
C2 - Fistula
C3 - Abscess
C4 - Mobility
C5 - Premature Exfoliation

R1 - Abnormal Root Resorption
R2 - Inter Radicular Radiolucency
R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
3 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
51	MTA	75	N	N	N	N	N	N	N	N	N	76	MTA	84	N	N	N	N	N	N	N	N	N
52	MTA	84	N	N	N	N	N	N	N	N	N	77	MTA	75	N	N	N	N	N	N	N	N	N
53	MTA	74	N	N	N	N	N	N	N	N	N	78	MTA	85	N	N	N	N	N	N	N	N	N
54	MTA	85	N	N	N	N	N	N	N	N	N	79	MTA	84	N	N	N	N	N	N	N	N	N
55	MTA	74	N	N	N	N	N	N	N	N	N	80	MTA	75	N	N	N	N	N	N	N	N	N
56	MTA	75	N	N	N	N	N	N	N	N	N	81	MTA	74	N	N	N	N	N	N	N	N	N
57	MTA	74	N	N	N	N	N	N	N	N	N	82	MTA	75	N	N	N	N	N	N	N	N	N
58	MTA	84	N	N	N	N	N	N	N	N	N	83	MTA	74	N	N	N	N	N	N	N	N	N
59	MTA	75	N	N	N	N	N	N	N	N	N	84	MTA	85	N	N	N	N	N	N	N	N	N
60	MTA	74	N	N	N	N	N	N	N	N	N	85	MTA	84	N	N	N	N	N	N	N	N	N
61	MTA	74	N	N	N	N	N	N	N	N	N	86	MTA	75	N	N	N	N	N	N	N	N	N
62	MTA	85	N	N	N	N	N	N	N	N	N	87	MTA	84	N	N	N	N	N	N	N	N	N
63	MTA	74	N	N	N	N	N	N	N	N	N	88	MTA	74	N	N	N	N	N	N	N	N	N
64	MTA	75	N	N	N	N	N	N	N	N	N	89	MTA	84	N	N	N	N	N	N	N	N	N
65	MTA	84	N	N	N	N	N	N	N	N	N	90	MTA	85	N	N	N	N	N	N	N	N	N
66	MTA	74	N	N	N	N	N	N	N	N	N	91	MTA	75	N	N	N	N	N	N	N	N	N
67	MTA	75	N	N	N	N	N	N	N	N	N	92	MTA	84	N	N	N	N	N	N	N	N	N
68	MTA	85	N	N	N	N	N	N	N	N	N	93	MTA	74	N	N	N	N	N	N	N	N	N
69	MTA	74	N	N	N	N	N	N	N	N	N	94	MTA	75	N	N	N	N	N	N	N	N	N
70	MTA	75	N	N	N	N	N	N	N	N	N	95	MTA	74	N	N	N	N	N	N	N	N	N
71	MTA	84	N	N	N	N	N	N	N	N	N	96	MTA	84	N	N	N	N	N	N	N	N	N
72	MTA	84	N	N	N	N	N	N	N	N	N	97	MTA	75	N	N	N	N	N	N	N	N	N
73	MTA	75	N	N	N	N	N	N	N	N	N	98	MTA	84	N	N	N	N	N	N	N	N	N
74	MTA	74	N	N	N	N	N	N	N	N	N	99	MTA	85	N	N	N	N	N	N	N	N	N
75	MTA	85	N	N	N	N	N	N	N	N	N	100	MTA	75	N	N	N	N	N	N	N	N	N

C1 - Pain
C2 - Fistula
C3 - Abscess
C4 - Mobility
C5 - Premature Exfoliation

R1 - Abnormal Root Resorption
R2 - Inter Radicular Radiolucency
R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
6 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
1	FC	84	N	N	N	N	N	N	N	N	N	26	FC	74	N	N	N	N	N	N	N	N	N
2	FC	75	N	N	N	N	N	N	N	N	N	27	FC	84	N	N	N	N	N	N	N	N	N
3	FC	74	N	N	N	N	N	N	N	N	N	28	FC	85	N	N	N	N	N	N	N	N	N
4	FC	84	N	N	N	N	N	N	N	N	N	29	FC	74	N	N	N	N	N	N	N	N	N
5	FC	85	N	N	N	N	N	N	Y	Y	N	30	FC	75	N	N	N	N	N	N	N	N	N
6	FC	74	N	N	N	N	N	N	N	N	N	31	FC	74	N	N	N	N	N	N	N	N	N
7	FC	84	N	N	N	N	N	N	Y	Y	N	32	FC	84	N	N	N	N	N	N	N	N	N
8	FC	85	N	N	N	N	N	N	N	N	N	33	FC	85	N	N	N	N	N	N	N	N	N
9	FC	74	N	N	N	N	N	N	N	N	N	34	FC	84	N	N	N	N	N	N	N	N	N
10	FC	75	N	N	N	N	N	N	N	N	N	35	FC	85	N	N	N	N	N	N	N	N	N
11	FC	74	N	N	N	N	N	N	N	N	N	36	FC	84	N	N	N	N	N	N	N	N	N
12	FC	74	N	N	N	N	N	N	N	Y	N	37	FC	75	N	N	N	N	N	N	N	N	N
13	FC	85	N	N	N	N	N	N	N	N	N	38	FC	74	N	N	N	N	N	N	N	N	N
14	FC	84	N	N	N	N	N	N	N	N	N	39	FC	85	N	N	N	N	N	N	N	N	N
15	FC	74	N	N	N	N	N	N	N	Y	N	40	FC	74	N	N	N	N	N	N	N	N	N
16	FC	75	N	N	N	N	N	N	N	N	N	41	FC	84	N	N	N	N	N	N	N	N	N
17	FC	74	N	N	N	N	N	N	N	N	N	42	FC	85	N	N	N	N	N	N	N	N	N
18	FC	85	N	N	N	N	N	N	N	N	N	43	FC	74	N	N	N	N	N	N	N	N	N
19	FC	84	N	N	N	N	N	N	N	N	N	44	FC	84	N	N	N	N	N	N	N	N	N
20	FC	74	N	N	N	N	N	N	N	N	N	45	FC	75	N	N	N	N	N	N	N	N	N
21	FC	85	N	N	N	N	N	N	N	N	N	46	FC	74	N	N	N	N	N	N	N	N	N
22	FC	84	N	N	N	N	N	N	N	Y	N	47	FC	84	N	N	N	N	N	N	N	N	N
23	FC	85	N	N	N	N	N	N	N	N	N	48	FC	75	N	N	N	N	N	N	N	N	N
24	FC	75	N	N	N	N	N	N	N	N	N	49	FC	85	N	N	N	N	N	N	N	N	N
25	FC	84	N	N	N	N	N	N	N	N	N	50	FC	84	N	N	N	N	N	N	N	N	N

C1 - Pain
C2 - Fistula
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R1 - Abnormal Root Resorption
R2 - Inter Radicular Radiolucency
R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
6 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
51	MTA	75	N	N	N	N	N	N	N	N	N	76	MTA	84	N	N	N	N	N	N	N	N	N
52	MTA	84	N	N	N	N	N	N	N	N	N	77	MTA	75	N	N	N	N	N	N	N	N	N
53	MTA	74	N	N	N	N	N	N	N	N	N	78	MTA	85	N	N	N	N	N	N	N	N	N
54	MTA	85	N	N	N	N	N	N	N	N	N	79	MTA	84	N	N	N	N	N	N	N	N	N
55	MTA	74	N	N	N	N	N	N	N	N	N	80	MTA	75	N	N	N	N	N	N	N	N	N
56	MTA	75	N	N	N	N	N	N	N	N	N	81	MTA	74	N	N	N	N	N	N	N	N	N
57	MTA	74	N	N	N	N	N	N	N	N	N	82	MTA	75	N	N	N	N	N	N	N	N	N
58	MTA	84	N	N	N	N	N	N	N	N	N	83	MTA	74	N	N	N	N	N	N	N	N	N
59	MTA	75	N	N	N	N	N	N	N	N	N	84	MTA	85	N	N	N	N	N	N	N	N	N
60	MTA	74	N	N	N	N	N	N	N	N	N	85	MTA	84	N	N	N	N	N	N	N	N	N
61	MTA	74	N	N	N	N	N	N	N	N	N	86	MTA	75	N	N	N	N	N	N	N	N	N
62	MTA	85	N	N	N	N	N	N	N	N	N	87	MTA	84	N	N	N	N	N	N	N	N	N
63	MTA	74	N	N	N	N	N	N	N	N	N	88	MTA	74	N	N	N	N	N	N	N	N	N
64	MTA	75	N	N	N	N	N	N	N	N	N	89	MTA	84	N	N	N	N	N	N	N	N	N
65	MTA	84	N	N	N	N	N	N	N	N	N	90	MTA	85	N	N	N	N	N	N	N	N	N
66	MTA	74	N	N	N	N	N	N	N	N	N	91	MTA	75	N	N	N	N	N	N	N	N	N
67	MTA	75	N	N	N	N	N	N	N	N	N	92	MTA	84	N	N	N	N	N	N	N	N	N
68	MTA	85	N	N	N	N	N	N	N	N	N	93	MTA	74	N	N	N	N	N	N	N	N	N
69	MTA	74	N	N	N	N	N	N	N	N	N	94	MTA	75	N	N	N	N	N	N	N	N	N
70	MTA	75	N	N	N	N	N	N	N	N	N	95	MTA	74	N	N	N	N	N	N	N	N	N
71	MTA	84	N	N	N	N	N	N	N	N	N	96	MTA	84	N	N	N	N	N	N	N	N	N
72	MTA	84	N	N	N	N	N	N	N	N	N	97	MTA	75	N	N	N	N	N	N	N	N	N
73	MTA	75	N	N	N	N	N	N	N	N	N	98	MTA	84	N	N	N	N	N	N	N	N	N
74	MTA	74	N	N	N	N	N	N	N	N	N	99	MTA	85	N	N	N	N	N	N	N	N	N
75	MTA	85	N	N	N	N	N	N	N	N	N	100	MTA	75	N	N	N	N	N	N	N	N	N

C1 - Pain
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R1 - Abnormal Root Resorption
R2 - Inter Radicular Radiolucency
R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
9 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
1	FC	84	N	N	N	N	N	N	N	N	N	26	FC	74	N	N	N	N	N	N	N	N	N
2	FC	75	N	N	N	N	N	N	N	N	N	27	FC	84	N	N	N	Y	N	N	Y	Y	N
3	FC	74	N	N	N	N	N	N	N	N	N	28	FC	85	N	N	N	N	N	N	N	N	N
4	FC	84	N	N	N	N	N	N	N	N	N	29	FC	74	N	N	N	N	N	N	N	N	N
5	FC	85	N	N	N	N	N	N	Y	Y	N	30	FC	75	N	N	N	N	N	N	N	N	N
6	FC	74	N	N	N	N	N	N	N	N	N	31	FC	74	N	N	N	N	N	N	N	Y	N
7	FC	84	N	N	N	Y	N	N	Y	Y	N	32	FC	84	N	N	N	N	N	N	N	N	N
8	FC	85	N	N	N	N	N	N	N	N	N	33	FC	85	N	N	N	N	N	N	N	N	N
9	FC	74	N	N	N	N	N	N	N	N	N	34	FC	84	N	N	N	N	N	N	N	N	N
10	FC	75	N	N	N	N	N	N	N	N	N	35	FC	85	N	N	N	N	N	N	N	N	N
11	FC	74	N	N	N	N	N	N	N	N	N	36	FC	84	N	N	N	N	N	N	N	N	N
12	FC	74	N	N	N	N	N	N	N	Y	N	37	FC	75	N	N	N	Y	N	N	Y	Y	N
13	FC	85	N	N	N	N	N	N	N	N	N	38	FC	74	N	N	N	N	N	N	N	N	N
14	FC	84	N	N	N	N	N	N	N	N	N	39	FC	85	N	N	N	N	N	N	N	N	N
15	FC	74	N	N	N	N	N	N	N	Y	N	40	FC	74	N	N	N	N	N	N	N	N	N
16	FC	75	N	N	N	N	N	N	N	N	N	41	FC	84	N	N	N	N	N	N	N	N	N
17	FC	74	N	N	N	N	N	N	N	N	N	42	FC	85	N	N	N	N	N	N	N	N	N
18	FC	85	N	N	N	N	N	N	N	N	N	43	FC	74	N	N	N	N	N	N	N	N	N
19	FC	84	N	N	N	N	N	N	N	N	N	44	FC	84	N	N	N	N	N	N	N	N	N
20	FC	74	N	N	N	N	N	N	N	N	N	45	FC	75	N	N	N	N	N	N	N	N	N
21	FC	85	N	N	N	N	N	N	N	N	N	46	FC	74	N	N	N	N	N	N	N	Y	N
22	FC	84	N	N	N	Y	N	Y	Y	Y	N	47	FC	84	N	N	N	N	N	N	N	N	N
23	FC	85	N	N	N	N	N	N	N	N	N	48	FC	75	N	N	N	N	N	N	N	N	N
24	FC	75	N	N	N	N	N	N	N	N	N	49	FC	85									
25	FC	84	N	N	N	N	N	N	N	N	N	50	FC	84									

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R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
9months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
51	MTA	75	N	N	N	N	N	N	N	N	N	76	MTA	84	N	N	N	N	N	N	N	N	N
52	MTA	84	N	N	N	N	N	N	N	N	N	77	MTA	75	N	N	N	N	N	N	N	N	N
53	MTA	74	N	N	N	N	N	N	N	N	N	78	MTA	85	N	N	N	N	N	N	N	N	N
54	MTA	85	N	N	N	N	N	N	N	N	N	79	MTA	84	N	N	N	N	N	N	N	N	N
55	MTA	74	N	N	N	N	N	N	N	N	N	80	MTA	75	N	N	N	N	N	N	N	N	N
56	MTA	75	N	N	N	N	N	N	N	N	N	81	MTA	74	N	N	N	N	N	N	N	N	N
57	MTA	74	N	N	N	N	N	N	N	N	N	82	MTA	75	N	N	N	N	N	N	N	N	N
58	MTA	84	N	N	N	N	N	N	N	N	N	83	MTA	74	N	N	N	N	N	N	N	N	N
59	MTA	75	N	N	N	N	N	N	N	N	N	84	MTA	85	N	N	N	N	N	N	N	Y	N
60	MTA	74	N	N	N	N	N	N	N	N	N	85	MTA	84	N	N	N	N	N	N	N	N	N
61	MTA	74	N	N	N	N	N	N	N	N	N	86	MTA	75	N	N	N	N	N	N	N	N	N
62	MTA	85	N	N	N	N	N	N	N	N	N	87	MTA	84	N	N	N	N	N	N	N	N	N
63	MTA	74	N	N	N	N	N	N	N	N	N	88	MTA	74	N	N	N	N	N	N	N	N	N
64	MTA	75	N	N	N	N	N	N	N	N	N	89	MTA	84	N	N	N	N	N	N	N	N	N
65	MTA	84	N	N	N	N	N	N	N	N	N	90	MTA	85	N	N	N	N	N	N	N	N	N
66	MTA	74	N	N	N	N	N	N	N	N	N	91	MTA	75	N	N	N	N	N	N	N	N	N
67	MTA	75	N	N	N	N	N	N	N	N	N	92	MTA	84	N	N	N	N	N	N	N	N	N
68	MTA	85	N	N	N	N	N	N	N	Y	N	93	MTA	74	N	N	N	N	N	N	N	N	N
69	MTA	74	N	N	N	N	N	N	N	N	N	94	MTA	75	N	N	N	N	N	N	N	N	N
70	MTA	75	N	N	N	N	N	N	N	N	N	95	MTA	74	N	N	N	N	N	N	N	N	N
71	MTA	84	N	N	N	N	N	N	N	N	N	96	MTA	84	N	N	N	N	N	N	N	N	N
72	MTA	84	N	N	N	N	N	N	N	N	N	97	MTA	75	N	N	N	N	N	N	N	N	N
73	MTA	75	N	N	N	N	N	N	N	N	N	98	MTA	84									
74	MTA	74	N	N	N	N	N	N	N	N	N	99	MTA	85									
75	MTA	85	N	N	N	N	N	N	N	N	N	100	MTA	75									

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R1 - Abnormal Root Resorption
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R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Master Chart
12 months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
1	FC	84	N	N	N	N	N	N	N	N	N	26	FC	74	N	N	N	N	N	N	N	N	N
2	FC	75	N	N	N	N	N	N	N	N	N	27	FC	84	N	N	N	Y	N	N	Y	Y	N
3	FC	74	N	N	N	N	N	N	N	N	N	28	FC	85	N	N	N	N	N	N	N	N	N
4	FC	84	N	N	N	N	N	N	N	N	N	29	FC	74	N	N	N	N	N	N	N	N	N
5	FC	85	N	N	N	N	N	N	Y	Y	N	30	FC	75	N	N	N	N	N	N	N	N	N
6	FC	74	N	N	N	N	N	N	N	N	N	31	FC	74	N	N	N	N	N	N	N	Y	N
7	FC	84	N	N	N	Y	N	N	Y	Y	N	32	FC	84	N	N	N	N	N	N	N	N	N
8	FC	85	N	N	N	N	N	N	N	N	N	33	FC	85	N	N	N	N	N	N	N	N	N
9	FC	74	N	N	N	N	N	N	N	N	N	34	FC	84	N	N	N	N	N	N	N	N	N
10	FC	75	N	N	N	N	N	N	N	N	N	35	FC	85	N	N	N	N	N	N	N	N	N
11	FC	74	N	N	N	N	N	N	N	N	N	36	FC	84	N	N	N	N	N	N	N	N	N
12	FC	74	N	N	N	N	N	N	N	Y	N	37	FC	75	N	N	N	Y	N	Y	Y	Y	N
13	FC	85	N	N	N	N	N	N	N	N	N	38	FC	74	N	N	N	N	N	N	N	N	N
14	FC	84	N	N	N	N	N	N	N	N	N	39	FC	85	N	N	N	N	N	N	N	N	N
15	FC	74	N	N	N	N	N	N	Y	Y	N	40	FC	74	N	N	N	N	N	N	N	N	N
16	FC	75	N	N	N	N	N	N	N	N	N	41	FC	84	N	N	N	N	N	N	N	Y	N
17	FC	74	N	N	N	N	N	N	N	N	N	42	FC	85	N	N	N	N	N	N	N	N	N
18	FC	85	N	N	N	N	N	N	N	N	N	43	FC	74	N	N	N	N	N	N	N	N	N
19	FC	84	N	N	N	N	N	N	N	N	N	44	FC	84	N	N	N	N	N	N	N	N	N
20	FC	74	N	N	N	N	N	N	N	N	N	45	FC	75	N	N	N	N	N	N	N	N	N
21	FC	85	N	N	N	N	N	N	N	N	N	46	FC	74	N	N	N	N	N	N	Y	Y	N
22	FC	84	N	N	N	Y	N	Y	Y	Y	N	47	FC	84									
23	FC	85	N	N	N	N	N	N	N	N	N	48	FC	75									
24	FC	75	N	N	N	N	N	N	N	N	N	49	FC	85									
25	FC	84	N	N	N	N	N	N	N	N	N	50	FC	84									

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Master Chart
12months evaluation

S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4	S.No	Group	Teeth	C1	C2	C3	C4	C5	R1	R2	R3	R4
51	MTA	75	N	N	N	N	N	N	N	N	N	76	MTA	84	N	N	N	N	N	N	N	N	N
52	MTA	84	N	N	N	N	N	N	N	N	N	77	MTA	75	N	N	N	N	N	N	N	N	N
53	MTA	74	N	N	N	N	N	N	N	N	N	78	MTA	85	N	N	N	N	N	N	N	N	N
54	MTA	85	N	N	N	N	N	N	N	N	N	79	MTA	84	N	N	N	N	N	N	N	N	N
55	MTA	74	N	N	N	N	N	N	N	N	N	80	MTA	75	N	N	N	N	N	N	N	N	N
56	MTA	75	N	N	N	N	N	N	N	N	N	81	MTA	74	N	N	N	N	N	N	N	N	N
57	MTA	74	N	N	N	N	N	N	N	N	N	82	MTA	75	N	N	N	N	N	N	N	N	N
58	MTA	84	N	N	N	N	N	N	N	N	N	83	MTA	74	N	N	N	N	N	N	N	N	N
59	MTA	75	N	N	N	N	N	N	N	N	N	84	MTA	85	N	N	N	N	N	N	N	Y	N
60	MTA	74	N	N	N	N	N	N	N	N	N	85	MTA	84	N	N	N	N	N	N	N	N	N
61	MTA	74	N	N	N	N	N	N	N	N	N	86	MTA	75	N	N	N	N	N	N	N	N	N
62	MTA	85	N	N	N	N	N	N	N	N	N	87	MTA	84	N	N	N	N	N	N	N	N	N
63	MTA	74	N	N	N	N	N	N	N	N	N	88	MTA	74	N	N	N	N	N	N	N	N	N
64	MTA	75	N	N	N	N	N	N	N	N	N	89	MTA	84	N	N	N	N	N	N	N	N	N
65	MTA	84	N	N	N	N	N	N	N	N	N	90	MTA	85	N	N	N	N	N	N	N	N	N
66	MTA	74	N	N	N	N	N	N	N	N	N	91	MTA	75	N	N	N	N	N	N	N	N	N
67	MTA	75	N	N	N	N	N	N	N	N	N	92	MTA	84	N	N	N	N	N	N	N	N	N
68	MTA	85	N	N	N	N	N	N	Y	Y	N	93	MTA	74	N	N	N	N	N	N	N	N	N
69	MTA	74	N	N	N	N	N	N	N	N	N	94	MTA	75	N	N	N	N	N	N	N	N	N
70	MTA	75	N	N	N	N	N	N	N	N	N	95	MTA	74	N	N	N	N	N	N	N	N	N
71	MTA	84	N	N	N	N	N	N	N	N	N	96	MTA	84	N	N	N	N	N	N	N	N	N
72	MTA	84	N	N	N	N	N	N	N	N	N	97	MTA	75	N	N	N	N	N	N	N	N	N
73	MTA	75	N	N	N	N	N	N	N	N	N	98	MTA	84									
74	MTA	74	N	N	N	N	N	N	N	N	N	99	MTA	85									
75	MTA	85	N	N	N	N	N	N	N	N	N	100	MTA	75									

C1 - Pain
C2 - Fistula
C3 - Abscess
C4 - Mobility
C5 - Premature Exfoliation

R1 - Abnormal Root Resorption
R2 - Inter Radicular Radiolucency
R3 - Periodontal Ligament Widening
R4 - Periapical Radiolucency
R5 - Internal Root Resorption

Histology Chart

SNo:	Characteristics	Formocresol	MTA	Control-Freshly Extracted Teeth
1	Integrity of odontoblast			
2	Dentine Bridge			
3	Intra Pulpal calcifications			
4	Inflammatory status		.	
5	Reversal /resting line			